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Editorial

It is our great pleasure to bring out the current issue of Journal of Environment sciences, volume V. In present issue, twenty three reviewed articles on thematic areas: Environmental impact assessment, Environmental chemistry, natural hazard, pollution, climate change, environment promotion, solid waste, sustainable development, disaster risk reduction, and other cross cutting issues have been included.

Environmental knowledge generated in different environmental sectors by different researchers, organization, institutions, academic institutions, has been assembled in the form of Journal of Environment Science volume V, 2019.

The journal aims to share environmental information and also promote to establish link among professionals, researchers, academicians and policy maker by providing them a common platform for further coordination and cooperation. We believe that the findings, outcomes, and suggestions obtained from these researches could serve for betterment of society and help to achieve our national ultimate goal of "*Sammriddha Nepal Sukhi Nepali"* in long run.

We acknowledge the valuable contribution from academicians, advisors reviewer, and authors for this publication. We expect that, with your cooperation, coordination and help, this journey will go on uninterrupted and unstopped leading toward endless success.

Thank you

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Use of cloth bags as an ecofrindly and cost effective method of cucurbit's fruitfly Bactocera cucurbiteae Coq. management on Sponge gourd Luffa cylindrical (L.) Roem. in Kathmandu, Nepal

Suroj Pokhrel, Ph.D
Former Secretary, Ministry of Agriculture, Land Management and Cooperative, Nepal
Lead Consultant (Agro-ecosystem Expert), FAO
Adjunct Professor, Agriculture and Forestry University
Email: surojpokhrel@yahoo.com

Abstract

An experiment was conducted during May-July, 2018 in Nagarjun-1, Kathmandu, to evaluate the effectiveness and timing of using cloth bags against cucurbit fruitfly Bactocera cucurbiteae Coq. on Sponge gourd Luffa cylindrical (L.) Roem. in Nagarjun-1, Kathmandu. The result revealed that the fruit size, weight and edible weight were significantly higher from the fruits cloth bagged with in a day of anthesis (T1) compare to fruits bagged on 2nd-3rd day of anthesis (T2) and control. The average length of the fruits from T1 was 65.2cm, compare to 56.7cm on T2 and 27.4cm on control. Similarly the average breath of the fruits on T1 was 20.13cm where it was 17.77cm on T2 and 11.60cm on control. Moreover, the average gross fruit weight on T1 was 674.57gm compare to 527.27gm of T2 and 212.33gm on control. The fruits from T1 were 100% edible, where, 76.65% from T2 and only 13.91% of fruit weight from control were edible. Use of cloth bag within a day of anthesis and wait for 10 days is recommended for the perfect management of this pest. Delay bagging on 2nd to 3rd day and wait up to 10 days of anthesis also can give the satisfactory results. Cloth bags prepared from house hold old clothes is cost effective and also is environmentally safe method of fruit fly management. Up-scaling the results and conduction of similar experiments on rest of other cucurbits are recommended for the adoption of cost effective and environment friendly method of cucurbit fruit fly management.

Key words: *Bagging, fruitfly, anthesis, environment, management.*

Introduction

Cucurbit fruit fly B. cucurbiteae Coq. is the most problematic insect pest of the cucurbits which attacks young and older fruits (Plantwise 2012). Alam 1969, Butani and Jotwani 1984 also reported that the Cucurbit fruit fly is the significant obstacles for economic production causing considerable damage of cucurbit fruits. It can attack more than 16 different types of Cucurbit crops viz., bottle gourd, bitter gourd, snake gourd, white gourd, ridge gourd, sponge gourd, cucumber, pumpkin, etc. The degree of damage varies by yield and quality on different Cucurbits. Yield losses due to fruit fly infestation on different Cucurbits vary from 19.19 to 69.96% (Kabir et al. 1991) and are the most serious in melon causing damage up to 100 percent (Atwal 1993, Nasiruddin et. al., 2004). Fruit fly damage starts from March and ends in August or September. Female flies lay eggs inside the fruit. The eggs hatch inside the infected fruits, get maggots, fruit get rotten and non-edible (Plantwise 2012). Numerous maggots may be seen within infected fruits. After 7 to

10 days the maggot will drop into the soil and pupate. The adult fly is pale yellow to brown with transparent wings having 2 spots on each (Fig.-1, Plantwise 2012).

Plantwise 2012 recommended collecting damaged fruits regularly and destroying them in a deep hole or soaking in water mixed with a chemical insecticide. In addition it is recommended using a food bait prepare from the yellow crushed ripened pumpkin applied with the drops of Malathion 50 EC 0.1 % solution over it and keep it in different places on the ground near the crop. Alternative solutions are covering the whole vines with young fruits with newspapers or waste clothes in kitchen garden cultivation to avoid the laying adults or to spray with a mixture of Malathion 50 EC at 1 ml/litre of water and 20 grams of sugar or molasses if more than 10% of fruits are infected and wait for 7 days for harvesting. Soil treatment with Malathion 5 % powder 20 kg per Ropani during winter combined with deep ploughing in winter to damage the pupae is also recommended (Plantwise 2012). Several authors highly advocated hand picking of infested fruits to reduce fruit fly damage on cucurbit vegetables. Nasiruddin & Karim (1992) recommended collection and destruction of infested fruits with larvae inside for reducing fruits fly population on snake gourd. Mitchell and Soul (1990) reported that this practice was widely used in USA for suppressing Mediterranean fruit fly Ceratitis capitata. Atwal (1993) suggested such mechanical control measures in farmer's fields as normal practice for effective control against this pest in India.

Figure-1: Adult and maggots of Cucurbit fruit fly, Bactocera cucurbiteae Coq. (Photo by NBAII)

Several authors recommended field sanitation for suppression of fruit fly population in many countries (Agarwal et al. 1987; Mitchell and Saul 1990; Smith 1992). Nasiruddin and karim (1992) found the bait traps a potential control measure for fruit fly, B. (Dacus) cucurbitae Coq., in snake gourd in kharif, 1990 at Comilla Bangladesh. They also found various sex pheromones dispensers and mashed sweet gourd traps effective for Fruit fly capture. Cuelure +methyl eugenol + naled captured significantly more fruit flies (269) in February to April, 2000 in Bangladesh. Narayena and Batra, 1960 recommended bagging cucurbit fruit with colorless polythene bags having a few holes made with an ordinary pin in Bangladesh. Aktaruzzamn et al. (1999) was able to suppress the fruit fly infestation significantly (5.53%) with bagging Cucumber fruits at 3rd

days of anthesis and retained for 5 days resulted higher fruit yield in Bangladesh. Islam et. al., 2018 recommended to adopt IPM technology for the better income from Bitter gourd cultivation. Kapoor (1993) developed and suggested a cluster method to control cucurbit fruit fly. However, it is very difficult to control cucurbit fruit fly due to its biology and nature of infestation. The chemical control is still popular to the farmers because of its quick and visible results but the resurgence and resistance of the pest and the high level of residues in market produce is a serious problem. Thus an environment friendly, cost effective and the practical alternative solution of cucurbit fruit fly management is very crucial. In this connection my wife is practicing fruit bagging with cloth bags against Cucurbit fruit fly in kitchen garden level since few year back. She claimed it is one of the environment friendly, cost effective and the practical alternative solution for Cucurbit fruit fly management for the resource poor farmers in Nepal. Thus, this experiment was designed, cunducted to evaluate the effectiveness and timing of using cloth bags against cucurbit fruitfly B. cucurbiteae Coq. on Bitter gourd and Sponge gourd in summer-rainy season, 2018.

Methods and materials

The experiment was conducted in Kathmandu valley in summer to rainy season in 2018 on Sponge gourd. The variety adopted was Narayani. Twenty seedlings were collected from Nucleous Vegetable Seed Production Centre Khumaltar, Lalitpur. One month old seedlings were planted at 3x1m distance in March 11, 2018. Vermi compost at the rate of 3 kg/plant was used at planting time in each planting pit. Special bamboo thatch was prepared before planting, for staking (Figure-2 and 4). Irrigation and weeding was carried out as per necessary. Non of the chemicals were used for manuring and plant protection. Actual observation of the experiment was taken after the use of the cloth bags in May Ist week when the vine were full grown and on fruiting stage (Figure-2).

Figure-2: Sponge gourd crops ready for the use of cloth bag against fruitfly Nagarjun-1, Kathmandu, 2018

Old and used house hold bed sheets, blanket covers, shirts and paints that are free of cost, were collected. The damaged portions were seassored out. Pieces of clothes from old bed sheets and blanket covers of 36x70 cm were prepared. The longitudinal margins were folded to each other and stitched with a sewing machine. One of the ends was also stitched to prepare the cloth bags

opening at the top. Half way 2 cm wide cross section from the top has been cut to prepare the tying strings while bagging the fruits. The legs and hand parts from paints and shirts were also taken for similar use (Figure-3 and 4).

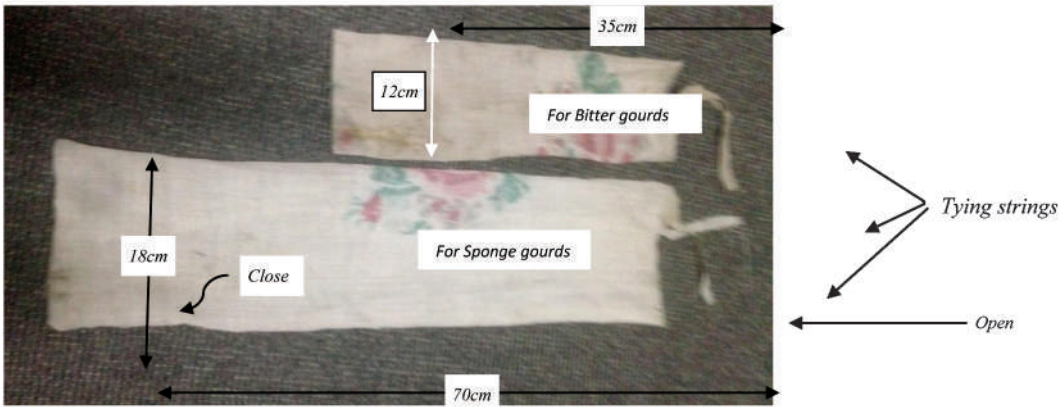

Figure-3: Cloth bags prepared from the old and used clothes for bagging against fruit fly, 2018

Three different treatments were adopted: use of cloth bag with in a day of anthesis, use of cloth bag on 2nd or 3rd day of anthesis and control (with out bagging). Anthesis was noticed with the immidate wilting of the corolla from the female flower. The treatments were replicated 30 times, 3 times at once and repeated each week with each crops. Each bags were removed after 10 days in case of treatment 1 and after 7-8 days in treatment 2 (all bags in 10 days of anthesis) (Figure-4 and 5). The Length, breath and weight together with the waight of the edible portion of the harvested fruits from each treatments were recorded. Collected deta were tabulated, analized and result was used for technical paper preparation.

Figure-4: Application of cloth bags on Sponge gourd fruits against fruit fly, Kathmandu, 2018

Figure-5: Harvested Sponge gourds after using cloth bag for 10 days against fruitfly, Kathmandu, 2018

Result and discussions

Effect of fruit cloth bag use on Sponge gourd production

The length, breath, weight and edible weight of Sponge gourd fruits was significantly higher with the fruits cloth bagged with in a day of anthesis (T1) compare to fruits bagged on 2nd-3rd day of anthesis (T2) and control. The average length of the fruits from T1 was 65.2cm, where, it was only 56.7cm on T2 and 27.4cm on control. Similarly the average breath of the fruits on T1 was 20.13cm compare to 17.77cm on T2 and 11.60cm on control. Likewise, the average gross fruit weight on T1 was 674.57gm compare to 527.27gm of T2 and 212.33gm of control. The fruits from T1 were 100% edible, where, 76.65% from T2 and only 13.91% of fruit weight from control were edible (Table-1, Fig.-6).

Table-1: Descriptive statistics (95% confidence interval for mean) of different variables on Sponge gourd fruit produced from dfferent treatments, Nagarjun-1, Kathmandu, 2018.

Variance	Treatment	Number	Mean	Std	SE	Lower bound	Upper bound	Minimum	Maximum
Length	T1*	30	65.2000	6.13301	1.11973	62.9099	67.4901	51.00	72.00
	T2**	30	56.7000	8.38780	1.53140	53.5679	59.8321	42.00	72.00
	T3	30	27.4000	11.41566	2.08420	23.1373	31.6627	12.00	50.00
	Total	90	49.7667	18.51392	1.95154	45.8890	53.6443	12.00	72.00
Breath	T1	30	20.1333	2.19299	.40038	19.3145	20.9522	15.00	23.00
	T2	30	17.7667	2.02882	.37041	17.0091	18.5242	15.00	24.00
	T3	30	11.6000	1.92264	.35102	10.8821	12.3179	8.00	16.00
	Total	90	16.5000	4.14688	.43712	15.6315	17.3685	8.00	24.00

Gross weight	T1	30	674.5667	117.12731	21.38442	630.8306	718.3027	400.00	805.00
	T2	30	527.2667	114.51756	20.90795	484.5051	570.0282	300.00	720.00
	T3	30	212.3333	72.86848	13.30390	185.1238	239.5429	100.00	330.00
	Total	90	471.3889	219.23112	23.10899	425.4718	517.3060	100.00	805.00
Edible weight	T1	30	674.5667	117.12731	21.38442	630.8306	718.3027	400.00	805.00
	T2	30	404.1333	151.36135	27.63467	347.6141	460.6526	100.00	650.00
	T3	30	29.5333	50.92641	9.29785	10.5171	48.5496	.00	150.00
	Total	90	369.4111	288.98753	30.46196	308.8838	429.9384	.00	805.00

*Straight shape **Curved shape

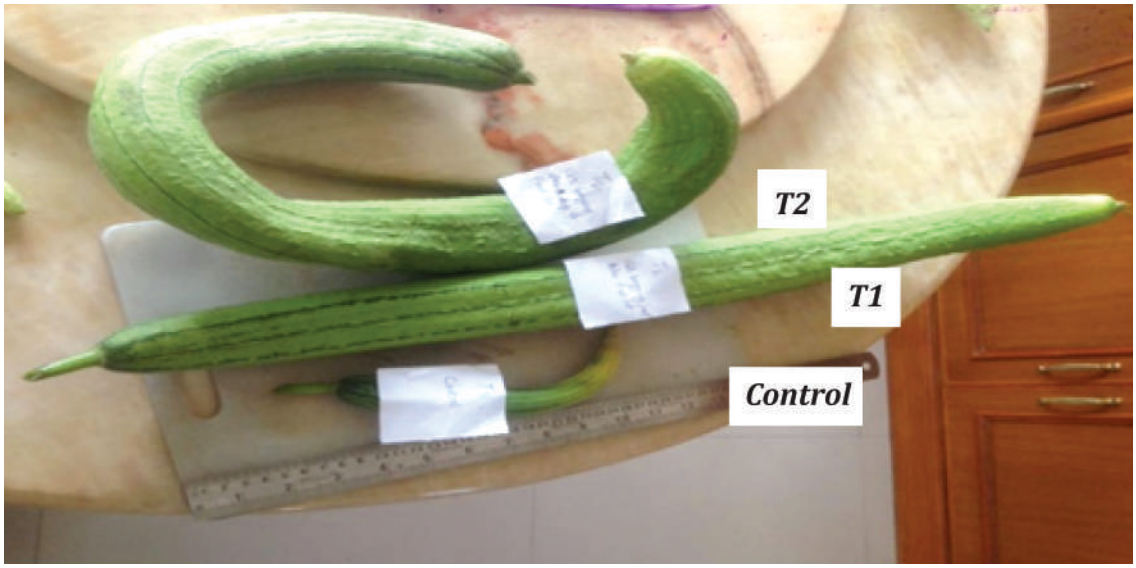

Figure-6: Effect of cloth bag use on Spongegourd fruit length, breath and weight, Kathmandu, 2018

Effect of cloth bag use on length of Sponge gourd fruit

The harvested fruits of Sponge gourd cloth bagged with in a day of anthesis (T1) were significantly longer than the fruits bagged on second-third day of anthesis (T2) and control. The average length of the fruits from T1 was 65.2cm compare to 56.7cm of T2 and 27.4cm of control. The average length of the fruits from T1 were 68.56cm in May, 66.80cm in June and 56.17cm in July 2018. Where, it was 62.33cm, 58.00cm, 45.00cm for T2 and 38.11cm, 26.53cm and 13.50cm for control in May, June and July respectively (Table-2, Fig.-7).

The average length of the fruits were 13.04% shorter for T2 and 57.98% shorter for control compare to T1. The shortness of the fruits were increasing over the months. The average length of the fruits on T2 and control were shorter by 9.90%, 13.17%, 19.89% and 44.41%, 60.28%, 75.97% in May, June and July respectively. Reduction of fruit length over the months was mainly because of the heavy rain of mansoon and the population pressure of fruitfly as well (Table-2, Fig.-7).

Table-2: two ways ANOVA for fruit length (cm) of Sponge gourd, Nagarjun-1, Kathmandu, 2018.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected model	24230.000[a]	8	3028.750	39.089	.000	.794
Intercept	222904.900	1	222904.900	2876.834	.000	.973
Treatment	23595.800	2	11797.900	152.265	.000	.790
Replication	164.867	2	82.433	1.064	.350	.026
Treat * Rep	469.333	4	117.333	1.514	.206	.070
Error	6276.100	81	77.483			
Total	253411.000	90				

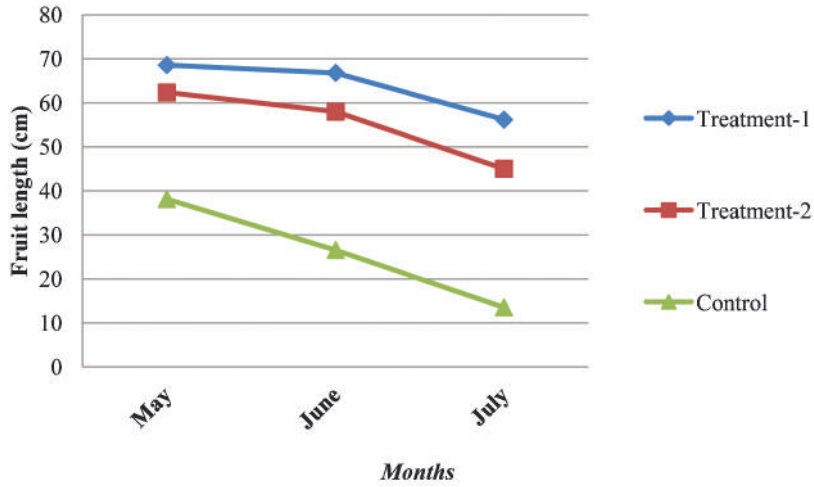

Figure-7: Effect of cloth bag use on length of Sponge gourd fruit, Nagarjun-1, Kathmandu, 2018

Effect of cloth bag use on breath of Sponge gourd fruit

The harvested fruits of Sponge gourd cloth bagged with in a day of anthesis (T1) were significantly thicker than the fruits bagged on second-third day of anthesis (T2) and control. The average breath of the fruits from T1 was 20.13cm compare to 17.77cm of T2 and 11.60cm of control. The average breath of the fruits from T1 were 21.67cm in May, 20.33cm in June and 17.33cm in July 2018. Where, it was 19.00cm, 17.40cm, 16.83cm for T2 and 13.11cm, 11.60cm and 9.33cm for control in May, June and July respectively (Table-3, Fig.-8).

The average breath of the fruits were 11.72% shorter for T2 and 42.37% shorter for control compare to T1. The shortness of the fruits were increasing over the months. The average breath of the fruits on T2 and control were shorter by 12.32%, 14.41%, 2.89% and 39.50%, 42.94%, 46.16% in May, June and July respectively. Reduction of fruit breath over the months is mainly because of the heavy rain in mansoon and the population pressure of fruitfly as well (Table-3, Fig.-8).

Table-3: Two way ANOVA for fruit breath (cm) of Sponge gourd, Nagarjun-1, Kathmandu, 2018.

Corrected model	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	1179.200[a]	8	147.400	33.986	.000	.770
Treatment	24502.500	1	24502.500	5649.594	.000	.986
Replication	1164.467	2	582.233	134.247	.000	.768
Treat * Rep	5.000	2	2.500	.576	.564	.014
Error	9.733	4	2.433	.561	.692	.027
Total	351.300	81	4.337			
Corrected model	26033.000	90				

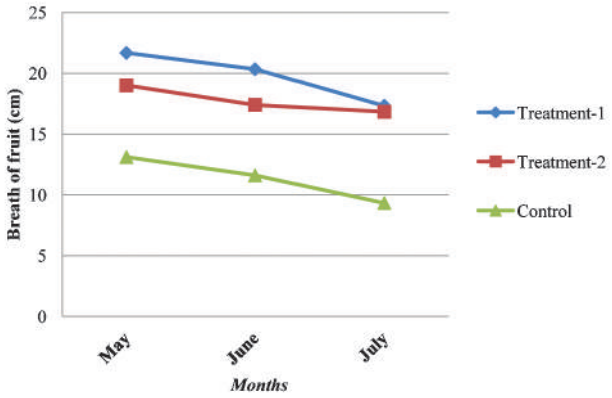

Figure-8: Effect of cloth bag use on breath of Sponge gourd fruit, Nagarjun-1, Kathmandu, 2018

Effect of cloth bag use on gross fruit weight of Sponge gourd

The gross weight of the harvested fruits of Sponge gourd cloth bagged with in a day of anthesis (T1) were significantly higher than the fruits bagged on second-third day of anthesis (T2) and control. The average gross fruit weight of the fruits from T1 was 674.57gm/fruit compare to 527.27gm/fruit of T2 and 212.33gm/fruit of control. The average gross fruit weight of the fruits from T1 were 744.56gm/fruit in May, 705.33gm/fruit in June and 492.67gm/fruit in July 2018. Where, it was 614.78gm/fruit, 533.40gm/fruit, 380.67gm/fruit for T2 and 281.33gm/fruit, 208.87gm/fruit, 117.5gm/fruit for control in May, June and July respectively (Table-4, Fig.-9).

Table-4: Two way ANOVA for gross fruit weight (gm/fruit) of Sponge gourd, Nagarjun-1, 2018.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected model	3393605.489[a]	8	424200.686	38.872	.000	.793
Intercept	19998673.611	1	19998673.611	1832.586	.000	.958
Treatment	3345399.489	2	1672699.744	153.279	.000	.791
Replication	19046.956	2	9523.478	.873	.422	.021

Treat * Rep	29159.044	4	7289.761	.668	.616	.032
Error	883937.900	81	10912.814			
Total	24276217.000	90				

The average gross weight of the fruits were 21.84% lower for T2 and 68.52% lower for control compare to T1. The lowerness of gross fruit weight were increasing over the months. The average gross fruit weight on T2 and control were lower by 17.43%, 24.38%, 22.73% and 62.22%, 70.39%, 76.15% in May, June and July respectively. Reduction of gross fruit weight over the months was mainly because of the heavy rain in monsoon and the population build up of fruitfly as well (Table-4, Fig.-9).

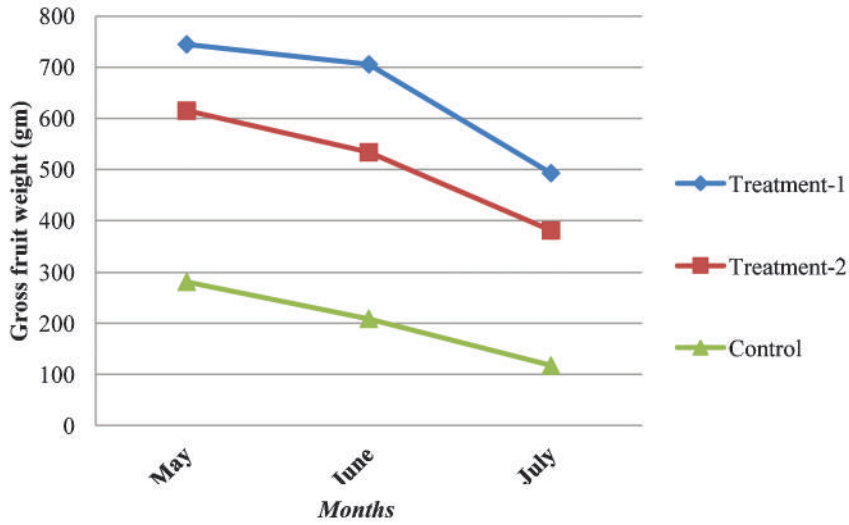

Figure-10: Effect of cloth bag use on edible weight of Sponge gourd fruit, Nagarjun-1, Kathmandu, 2018

All harvested fruits (100%) from T1 was edible and completely protected from the fruit fly. Where on an average 76.65% from T2 and only 13.91% fruit weight from control were edible. Rest 23.35% from T2 and 86.09% fruit weight from control were not edible and damaged by cucurbit fruit fly. The ediblity of the fruits from T2 and control was decreased significantly over the months where, it was constant and was 100% with T1. The editability of the fruits from T2 and control were 80.10%, 83.194%, 45.36% and 25.20%, 7.91%, 00.00% in May, June and July respectively (Table-6, Fig.-11).

Table-6: Percentage of edible weight to gross fruit weight of Sponge gourd fruit, Nagarjun-1, 2018

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected model	6326598.089[a]	8	790824.761	57.911	.000	.851
Intercept	12281811.211	1	12281811.211	899.376	.000	.917

Treatment	6295273.489	2	3147636.744	230.496	.000	.851
Replication	17622.422	2	8811.211	.645	.527	.016
Treat * Rep	13702.178	4	3425.544	.251	.908	.012
Error	1106129.700	81	13655.922			
Total	19714539.000	90				

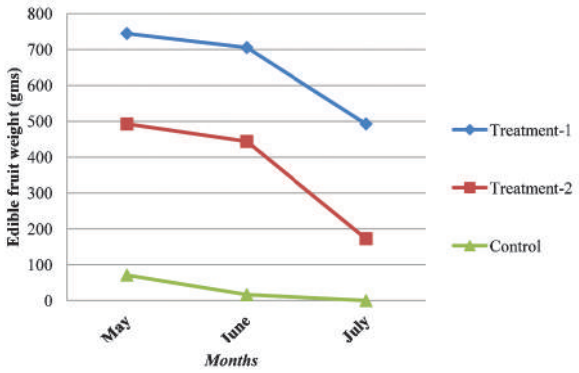

Figure-10: Effect of cloth bag use on edible weight of Sponge gourd fruit, Nagarjun-1, Kathmandu, 2018

All harvested fruits (100%) from T1 was edible and completely protected from the fruit fly. Where on an average 76.65% from T2 and only 13.91% fruit weight from control were edible. Rest 23.35% from T2 and 86.09% fruit weight from control were not edible and damaged by cucurbit fruit fly. The ediblity of the fruits from T2 and control was decreased significantly over the months where, it was constant and was 100% with T1. The editability of the fruits from T2 and control were 80.10%, 83.194%, 45.36% and 25.20%, 7.91%, 00.00% in May, June and July respectively (Table-6, Fig.-11).

Table-6: Percentage of edible weight to gross fruit weight of Sponge gourd fruit, Nagarjun-1, 2018

Months	Treatment-1	Treatment-2	Control
May	100	80.10	25.20
June	100	83.19	7.91
July	100	45.36	0
Average	100	76.65	13.91

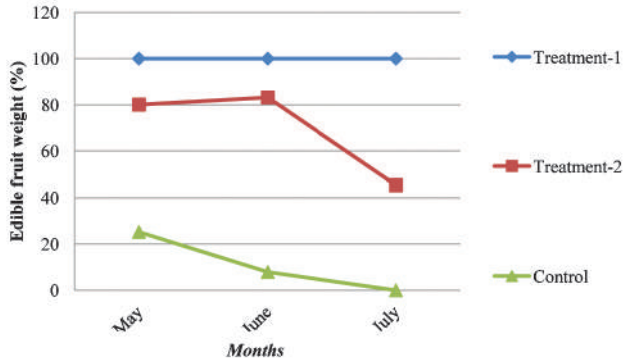

Figure-11: Percentage of edible weight of Sponge gourd fruit, Nagarjun-1, 2018

Conclusion and recommendation

Cucurbit fruit fly is a serious pest of Sponge gourd in Kathmandu valley. Adoption of management practices is most important. Chemical control of fruit fly is not only dangerous to human health but is equally dangerous to agro-ecosystem services. Use of pheromone and mass trapping also cannot give perfect management of this pest. Use of cloth bags within a day of anthesis and wait for 10 days is recommended for the perfect management of this pest. Delay bagging on 2nd to 3rd day and wait up to 10 days of anthesis also can give fairly satisfactory results against control.

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Flood Hazard Mapping and Vulnerability Analysis of Bishnumati River, Kathmandu

Deepa Pradhan[1*], Tirtha Raj Adhikari[2]
[1]GoldenGate International College, Tribhuvan University
[2]Central Department of Hydrology and Meteorology, Tribhuvan University
*Corresponding Address: evergreendeepa5@gmail.com

Abstract

*Flood is considered a major disaster in Nepal from natural, physical, social, cultural and economic impact, and the degree of social and economic impact and quantitative destructions it causes. The main objective of this study was to analyze the flood frequency, prepare its inundation map and determine the vulnerable areas of Bishnumati River. Bishnumati catchment area of 99 sq km was taken for study. Flood frequency was analyzed using Gumbel distribution. Flood hazard mapping is one of the measures to identify the inundation level. Inundation mapping was prepared by using 2D-hydraulic model HEC-RAS 5.0.4 with integration of Arc-GIS 10.2.1 and Hec-geoRAS10. 30*30 spatial resolution of DEM was used for mapping. The observed value and calculated value was calibrated and validated. Spatial Multi criteria decision analysis along with analytical hierarchy process was constructed to determine the vulnerable areas. The discharge value was seen to be simultaneously increasing with respect to the return periods. It shows flood depth directly affected by the flood intensity. Three hazardous zones were classified on the basis of depth. Spatial Multi criteria analysis helped to prepare vulnerability mapping obtaining the highly vulnerable areas. 1600 household settlements were in highly vulnerable areas.*

Keywords : *Hazard ,vulnerable ,inundation, HEC-RAS, HEC-geoRAS*

Introduction

Flood is an overflow of a large amount of water beyond its normal limits. It can also be referred to the inflow of the tide or the backflow of the river; which occurs at the location where the rivers meet. So, a flood occurs when water overflows or inundates land that's normally dry. This can happen in a multitude of ways. Most common is when rivers or streams overflow their banks. Excessive rain, a ruptured dam or levee, rapid ice melting in the mountains, or even an unfortunately placed beaver dam can overwhelm a river and send it spreading over the adjacent land, called a floodplain. From a geological perspective, floods are natural consequences of stream flow in a continually changing environment. The streams receive most of their water input from precipitation and the amount that falling in drainage basin varies from day to day. Based on the role of precipitation, the amount and time which precipitation takes places is not constant for any given area. As the amount of water increases, the stream must adjust its velocity and cross section in order to form a balance. The discharge increases as more water is added through rainfall, tributary streams, or from the groundwater seeping into the stream resulting in floods due to increase of width, depth and velocity of streams (Shravanya, 2016). In South Asia, there is an increasing trend in the number of people affected by floods. India has the highest number of people affected by floods, followed by Bangladesh. In the period from 1976 to 2005, 332 flood

events killed about seven million and affected a billion people in South Asia (Shrestha, 2008). Developing countries are particularly vulnerable to extreme weather events, especially given the current climatic instability, which can cause substantial economic damage (Monirul, 2003). An extreme event occurred in July 2002 when 26 floods occurred in the Kathmandu Valley taking the lives of 28 people, leaving 283 people affected and property losses of 54,455,000 Nepalese Rupees (USD 545,550). According to recent study on disasters by National Emergency Operation Center under Ministry of Home Affairs (MoHA) has revealed that from 2068- 2074, there were 664 dead, 443 disappeared and 221 injured in overall places of Nepal. Thus, ranking the food as the fourth most dangerous disaster by MoHA. The main objective of my study is to determine the flood hazard map and to analyse the vulnerability of Bishnumati River, Kathmandu.

Materials and methods

The Bisnumati River, flowing in the Kathmandu Valley, originates at Tokha on Sivapuri Mountain, north of Kathmandu. It flows through the western part of old Kathmandu city. It lies in the 27° 41' 00" N latitudes and 85° 19' 00" E. Bishnumati catchment of area 99 sq.km with the outlet at confluence of Bishnumati and Bagmati river of Kathmandu is taken as the study area. The upstream of the catchment consist of cultivation and forest area and the downstream is more densely populated. Further, the channel of the river is modified by different artificial levees, which affects the flow of water in the river. Since the northern face of the valley receives more intense rainfall, there is the probability of flood disaster due to human intervention in the natural flow of river channel.

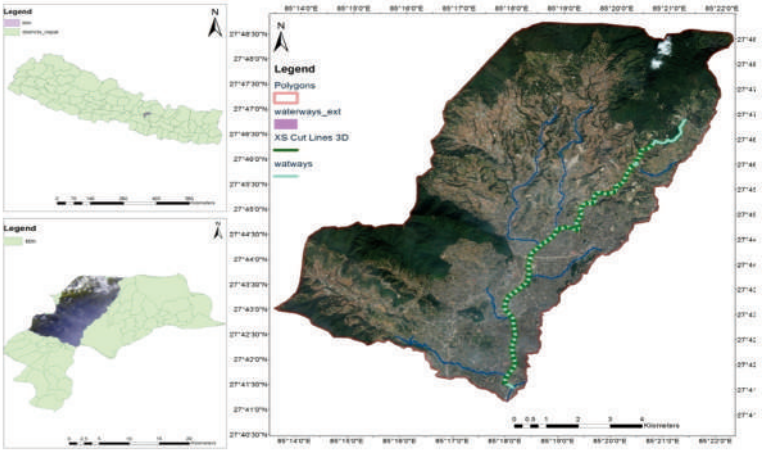

Figure 1: The location map of Bishnumati watershed, Kathmandu

With the process to be formulated gumbel equation was widely followed for flood frequency analysis. The equation for Gumbel's distribution as well as to the procedure with a return period T is given as, XT = Xav + K * SDV Where; XT = value of variate with a return period, Xav = mean of the variate, SDV = Standard deviation of the sample, K = Frequency factor expressed as K = (yT – 0.577)/1.2825; yT = reduced variate expressed by yT (T – 1) = - (LN * LN); T = return period.

HEC-RAS software was used. HEC-RAS is a 2D flow model in which the stream morphology is represented by a series of cross sections indexed by river station. The application of HEC-RAS was to obtain flood extent and depth. Each cross section is defined by a series of lateral and elevation coordinates that are typically obtained from DEM. DEM derived from ASTER Calibration and Validation of the data was to be done which compares the observed discharge, and then analyzes the parameters that influence the modeling results. Multi criteria Decision Analysis with Geographical Information Systems is to provide more flexible and more accurate decisions to the decision makers in order to evaluate the effective factors. Some of the causative factors for flooding in watershed are taken into account as annual rainfall, size of watershed, basin slope, gradient of main drainage channel, drainage density, land use and the type of soil. In the application of Multi-criteria decision analysis, the Analytic Hierarchy Process, which is a structured technique for dealing with complex decisions, was applied. Rather than prescribing a correct decision, the AHP helps decision makers find the one that best suits their needs and their understanding of the problem. MCDA is carried out on two phases: Pairwise comparision method and ranking method.

Table 1: The Fundamental Scale for Pair wise Comparisons (Saaty, 1990)

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one element over another.
5	Strong importance	Experience and judgment strongly favour one element over another.
7	Very strong importance	One element is favoured very strongly over another; its dominance is demonstrated in practice.
9	Extreme importance	The evidence favouring one element over another is of the highest possible order of affirmation.

The Digital Terrain Model was generated from SRTM3 - Shuttle Radar Topography Mission Global Coverage (~90m) Version 2. Based on field observation, Google earth image interoperation and land cover maps provided by ICIMOD, 5 land use classes were identified as forest, barren land, agricultural land, shrub land, grassland. The aspect considered in the study area was derived from DEM. Aspect were classified into Nine classes (North, Northeast, East, Southeast, South, Southwest, West, Northwest, North). As for slope, they were classified in to five categories. As 00 to 150 (Gentle slopes), 150 to 300 (moderate slopes), 450 to 600 (Highly steeps slopes) and >600 extremely steep slopes.

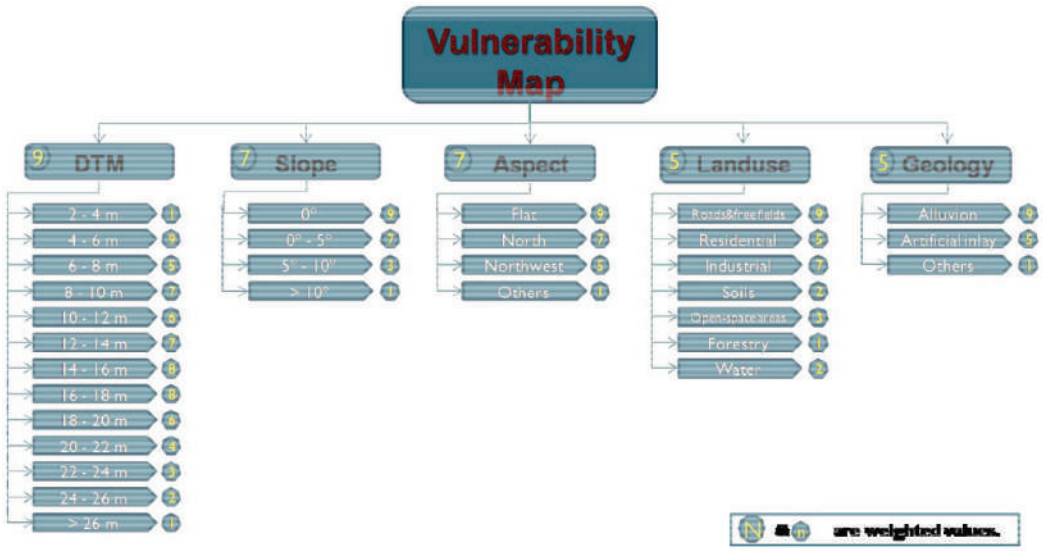

Figure 2: Hierarchical structure of the parameters that represent vulnerability.

Results

Analysis of flood frequency: Flood frequency analysis was done through Gumbel distribution. The below figure shows the frequency analysis within 2 years. 17 years data was taken for further calculation of discharge.

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Table 2: Discharge in accordance with return periods through Gumbel calculation

Return periods (Tr)	Discharge(m^3/s)
2	2.87099
5	4.288632
10	5.227235
20	6.127565
25	6.413162
30	6.645503
40	7.010665
50	7.292951
60	7.523108
70	7.717421
80	7.885566
90	8.033762
100	8.166243

110	8.286026
120	8.395333
130	8.495851
140	8.588888
150	8.675481
200	9.036349
250	9.316075
500	10.18429
1000	11.05187

Flood hazard mapping

Figure 3 represents the inundation level of 20 and 50 year. It is indicated by high hazard, medium and low hazard zone. The depth ranges from 0.003295898m to 6.538085938m in 20 year return period and 0.00012207m to 6.5703125m in 50 year return period. The greater flow area coverage value is 319.58m² (20 YRP) and 323.39m² (50YRP) in Dallu region, which lies at lower elevation while the low area is 3.31m²(20 YRP) and 3.81m²(50YRP) in Pasikot region which lies at higher elevation. Mostly the lower elevated regions seem to be in the range of high inundation.

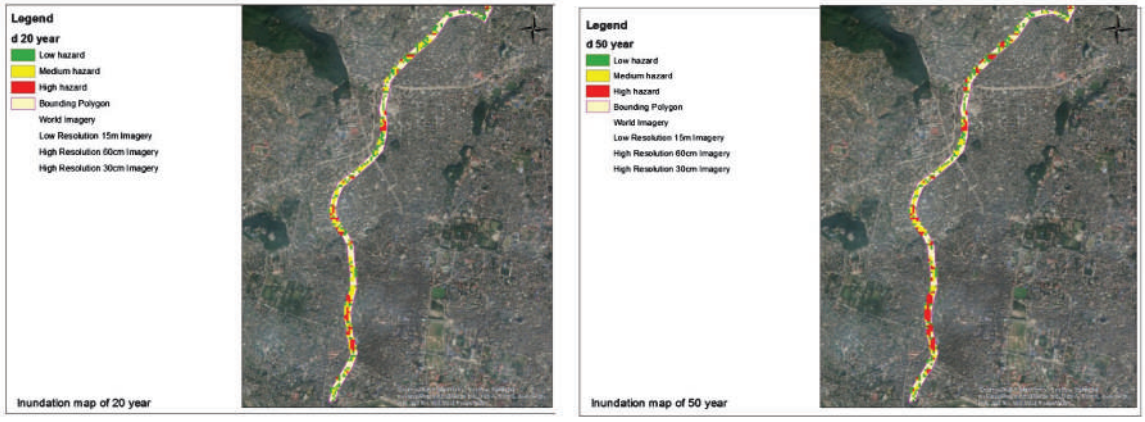

Figure 3: The inundation map 20 and 50 year return period

Calibration and Validation

Table 3: Calibrated value on the basis of depth

Station number	Station Name	Observed depth (m)	Caculated depth (m)	Return period	% of difference
1	Pasikot	0.28	0.19	2 Year	32
2	Pasikot	0.19	0.10	2 Year	47
3	Pasikot	0.22	0.21	2 Year	5
4	Tokha	1.80	1.50	2 Year	17

5	Tokha	1.21	0.79	2 Year	35
6	Khadga bhadrakali	1.52	2.01	2 Year	-32
7	Tokha saraswati	2.74	2.58	2 Year	6
8	Gongabu	0.30	0.26	2 Year	13
9	Balaju	0.30	0.30	2 Year	0
10	Dallu	1.48	1.48	2 Year	0
11	Teku	0.30	0.29	2 Year	3

Most observed data nearly matched the depth. Among the 11 sites observed, Balaju and Dallu region had no difference in observed and calculated value. The highest percentage of difference was seen near Pasikot region i.e. 47 while in highest negation was seen in Khadga Bhadrakali i.e. -32. It is only compared to 2 year return period, since it is the nearest return period having maximum probable of highest frequency.

Analysis of vulnerable areas: Figure 4 represents the vulnerable areas. It shows that there is more number of places which lies in no vulnerable zone. With the lower elevation, the highly vulnerable zone seems to be increasing and 1600 household settlements were found to be in highly vulnerable zone.

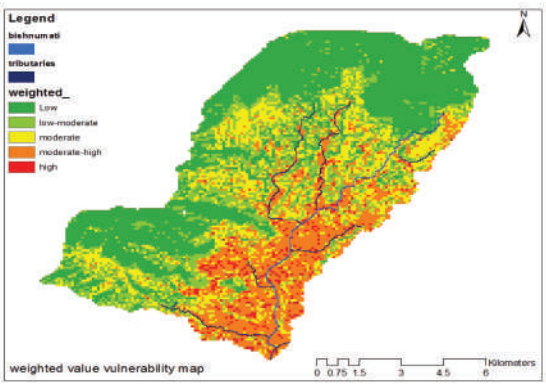

Figure 4: The vulnerability map of weighted value

Discussion

Applying the Gumbel's calculation, the maximum discharge was obtained. The discharge increases as more water is added through rainfall, tributary streams, or from the groundwater seeping into the stream resulting in floods due to increase of width, depth and velocity of streams (Shravanya, 2016). The record of extreme maximum discharge exhibits that the least discharge occurs in February and the greatest discharge occurs in August (Tamrakar, 2010). Since the rainfall is maximum in July, the flood level tends to be higher in that period of month i.e. 533.036 mm. The return period of 2, 5,10,20,50,100,200,250,500 and 1000 years have been seemingly increasing. Higher the depth, higher the chances of flooding in relation with the intensity of flood (Dangol et al., 2017). The hazardous region has been divided into three classes i.e. high hazard, medium and low hazard region. The high hazard region was found to be from Dallu to Bhimsenthan. (Rahmati et al., 2016) inundation area in 100-year return period is more than that in 50- year return period,

which is similar to this study but in comparison the difference in upstream is more, and some patches that are not inundated in 50-year return period are disappeared in 100-year flood while in this study area, difference in downstream is more. Among the 11 observed value (Table number 3), two places were near to 0 and three out of nine had approximate values near to 1. Despite the fact that statistical analysis was done there was negation in one or two places with certain difference in percentage. This proves that even we conduct the statistical analysis somewhat error is to be found, as stated in (Gupta et al., 2009).

Using the pair comparison method and the criteria important for evaluation, the vulnerable areas were determined. Mostly the vulnerable areas were seen at the downstream. The region which had higher depth and lower elevation were on the right bank of Bishnumati River. The ranking was divided into the five sectors indicating low hazard, high hazard, moderate, no hazard and safe. Multi Criteria Decision Analysis with Analytic Hierarchy Process in this study helped to determine the vulnerable areas in the watershed coverage. (Dangol et al., 2017) the vulnerable household varied in different return periods. (Dangol et al., 2017) The highly vulnerable settlements in 20 year return period was near about similar to this study i.e. 1600 household settlements. (Ozcan et al, 2010) 480 vulnerable buildings were obtained on the basis of three vulnerable zones while in this study the household settlements had been divided into five vulnerable zones.

Conclusion and recommendations

Flooding has been the areas which will assist in the proper future management of additional household settlement most severe disaster in the recent years, mostly in the monsoon and heavy rainfall areas. The frequency of the flood was analysed with respect to the variational rainfall in addition to this, flood hazard map was prepared using 2D-hydraulic model HEC-RAS and three hazardous zones were determined i.e High hazard, medium and low hazard zones. Spatial Multi Criteria Decision Analysis along with Analytic Hierarchy Process in this study helped to determine the vulnerable areas in the watershed coverage. 1600 household settlements were found in highly vulnerable zones. The following are some of the recommendations:

- The gauging stations should be established on major control points, preferably on bridges in the upper, middle and lower catchment.
- Well managed planning for the household settlement should be done. The remaining squatter settlements should be shifted as soon as possible.
- Streambank vegetation and riparian vegetation should be established to reduce erosion.
- The government should aim for sustainable urban drainage systems which would be adequate for mitigation of local floods, without creating new hazards downstream.

Acknowledgement

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Estimation of water use coefficient for assessing industrial water demand of various industries of Kathmandu valley

Rabin Malla*, Aashis Sapkota, Palpasa Prajapati
Center of Research for Environment, Energy and Water, Baluwatar, Kathmandu
*Corresponding address: rabin@creew.org.np

Abstract

Industries are backbone of economic growth for the development of countries. However, in case of Nepal there is inadequate data and information about industrial water use and the water demand supply of the sector. The aim of this study is to estimate water use coefficient for industrial water demand of various industry types located in the Kathmandu valley. The primary baseline data on amount of water used and number of employees were collected by conducting questionnaire survey. The water use coefficient is calculated by indirect methods. Among the surveyed industries, the major source of water used in industries is groundwater along withone other alternative source. The highest water use coefficient is calculated for the beverage industry (i.e. 4123.3 Liters per Employee per Day, LED) and the lowest coefficient is for lubricant industry (i.e. 33.3 LED). Therefore the highest water demand might be calculated for food and beverage industry compared to other type of industries.

Keywords: *Liters per Employee per Day (LED), Groundwater, Kathmandu Valley, industrial water demand, water use coefficient.*

Background

The social welfare and economic health of the country highly depends upon effective water management policies. For the sustainable water usage, necessary information are not processed. The focus on water management varies considerably from region-to-region, reflecting local scarcities, water prices and ecological health concerns (Blackhurst et al., 2010). Even the small water withdrawals can create significant ecological problems. Therefore, the withdrawal of water for domestic, industrial or agricultural purposes needs to be in such a way that the hydrologic system is balanced (Boero & Pasqualini, 2017; Scheele & Malz, 2007). Industrial and commercial area uses about 20% of the water withdrawn worldwide (Scheele & Malz, 2007). Although there has been considerable amount of research on agricultural and domestic water uses, only few have evaluated industrial water useespecially in the context of developing countries. The reason may be the lack of reliable information on water consumption by industries (Kumar, 2004).

The industrial sector faces several challenges, among which water scarcity is one of the major challenge, alongwith reliable water supply, rising water prices and seasonal water scarcity. However, the significant amount of water usage is also a key input to productive activities and employment (Worthington, 2010).Industry requires water for cooling, processing and manufacturing operations, power generation, sewerage, cleanup and sanitation, and fire protection

(Worthington, 2010). However, water demand is not the same for individual industry type in terms of both quantity and purpose. Hence, there is a need to estimate water use for each industry separately (Gleick et al., 2003).

It is very acceptable that urban water is getting increasingly scarce. Thus, it is inevitable to study the usage of water in all the sectors of water use. Since the industries have access to groundwater on their own, it is very difficult to control the amount of water use. Optimum use is necessary for the sustainability of water resources. Industrial development is undoubtedly necessary for national development. There are statistical records about the revenue and other economic activities of industries in Nepal, however no adequate data are found about water use by industries. With the recent political stability in the country, the economic sector is expected to boom in the upcoming years, thus making the industrial development more rapid. This rapid industrial development will create water demand in the industrial sectors to increase. Hence it is very important to know the amount of water used in producing a particular product. Comprehensive study of water uses will contribute to the demand-side management at present and in future research and decision making. The aim of this study is to estimate the water use coefficient of each industry type for assessing present and future water demand.

Materials and Methods

Study area

Kathmandu valley is located between 27º32'13" and 27º49'10" N and 85º11'31" and 85º31'38" E.It has an average altitude of 1350m above the sea level. The elevation of the valleyranges from 1212 to 2722 m above mean sea level (Thapa et al., 2016). Kathmandu receives an average rainfall of 1343 mm of rainfall per year, or 111.9 mm per month. Kathmandu valley is the most populous urban region of the country. The city has had economic, administrative and political importance for hundreds of years. It has 3 districts Kathmandu, Lalitpur and Bhaktapur. In the modern world, Kathmandu is a developing city with several plans being implemented for development. Amidst this development, ancient monuments can be seen scattered all around the valley. Like many cities of the developing world, Kathmandu is also facing problems like rapid population expansion and socio-economic problems following the growth (Thapa et al., 2008).

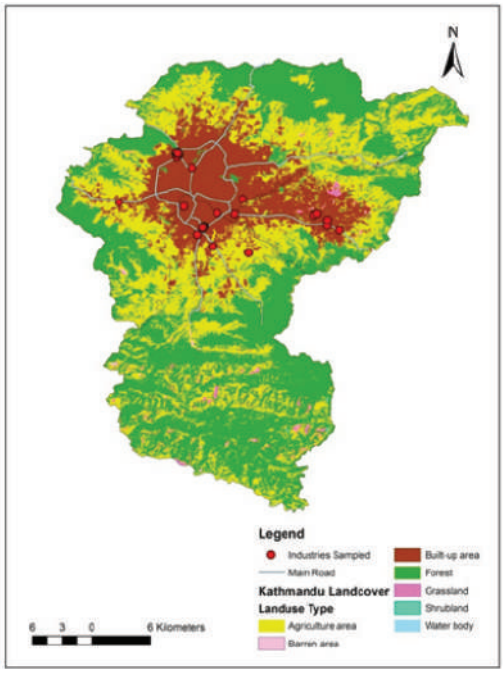

Figure 5: Land use land cover map of Kathmandu valley

Data collection

The survey was conducted during July-August, 2017. During the survey, transect walk was done and questionnaire was filled when conducting face to face interview with focal person of the industry. The survey included 70 industries which are either individual industry or within various industrial zone. The survey covered various types of industries from textiles to beverages, from food products to paper and pulp industries representing the overall types of industries operating in the Kathmandu valley. The questionnaire was developed after rigorous literature review and consultation with water resource management expert. It is assumed that the information provided by the focal person during the interview is the actual and highly reliable. The questionnaire covered questions related to the amount of water used per day, types of industry, source of water, capacity of water collection and filled per day, materials production capacity per day, the labor that used in industry, etc.

Water use coefficient estimation method

Coefficient based method or unit used coefficient methods are widely used and are particularly used in urban and municipal water use planning (Billings and Jones, 1996).Water use coefficients are commonly used for the constant requirements of water for the material production in the industry. Coefficient based estimation methods are more robust for calculation separately for specific categories i.e. industry, commercial or residential (NRC, 2002). This simple estimation methods ignores the trends of water conservation technologies, technological changes, economic forces and the optimal level of disaggregation of water use categories. Industrial water coefficients are defined as water withdrawals associated with the activities carried out at industry level. They are measured as the physical quantity of water withdrawn for production in each industrial sector. The reciprocal of water coefficients can also be interpreted as a measure of water productivity. The coefficient methods estimate that the water use (W) as the product of relevant explanatory variable X (number of employees, number of single-family homes, etc.) and a dimensionally consistent water use coefficient C (gallons per employee or gallons per single family home) i.e. W = XC (NRC, 2002) or

$$\textit{Water use coefficient (C)} = \frac{\textit{(Amount of water used in a day in the industry (W))}}{\textit{(No.of employee in the industry (X))}}$$

Results and discussion

Industrial survey

A total of 70 industries from 25 types were surveyed for this study and the number of employees in each industry is shown in figure 2. Highest number of staffs was employed in the food production industries followed by dairy industry.

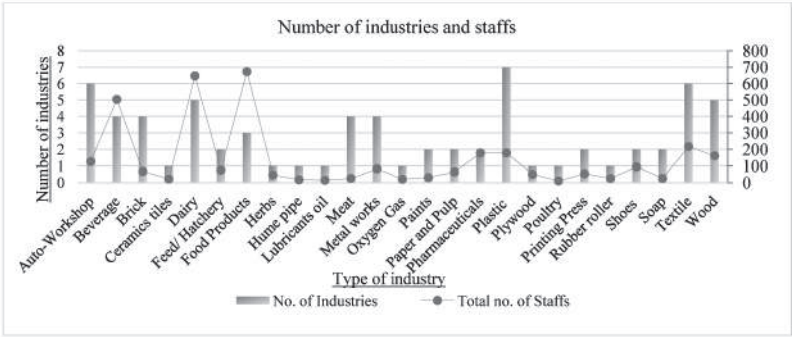

Figure 2: Number of industries surveyed

Sources of water used

Different type of industries used different sources of water. Groundwater is one of the major sources of water and widely used by the industries. Out of the total surveyed industries, 23% industry used only groundwater, but in most cases (46%) one alternative source along with groundwater is also used. The alternative sources are tanker water, government water supply and supply by the industrial districts. 11% of the industries used two alternative sources along with groundwater source. Water supplied by the government is sufficient to 4% of the industries only as shown in figure 3. Groundwater is found to be the most used source of water but the sustainability of the resource is questionable. Many problems related to groundwater which are seen worldwide, like massive drawdown in groundwater level, groundwater environment pollution, are also already seen in Kathmandu valley. Various water management options need to be adopted in the long run. Industries should implement water management strategies to decrease water consumption and wastewater generation at both factory level and regional level for sustainable water use (Pham et al., 2016).

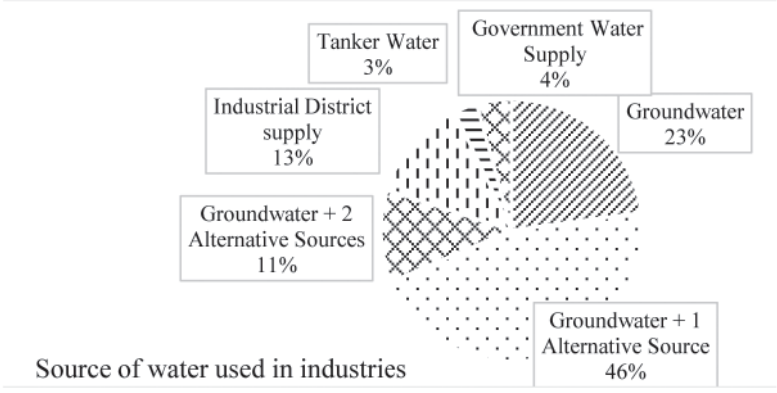

Figure 3: Sources of water used by industries in Kathmandu valley

Industrial water demand coefficient

Estimation of water use coefficient for each industry types are calculated and these coefficients are expressed in Liters per Employee per Day (LED) as shown in table 3. Among these 25type of industries, the highest water use coefficient is in beverage industry i.e. 4123.3 LED followed by oxygen gas company (952.4 LED) and auto workshop (785.4 LED), but the lowest water use coefficient is estimated for lubricant industry (33.3 LED) and second lowest paper and pulp industry (37.6 LED) respectively. This data shows that the food beverage company need around 120 time more water compared to the lubricant and paper and pulp industry. So the water demand is obviously higher in beverage industry compared other industries. While an estimation of water demand for the future in urban area, beverage industry should consider the number and possibility for the future expansion.

Table 4: Water demand coefficients of various industries in Kathmandu valley

S. No.	Category	AverageWD (LED)	13	Oxygen gas	952.4
1	Auto workshop	785.4	14	Paints	225.4
2	Beverage	4123.3	15	Paper and pulp	37.6
3	Brick	629.2	16	Pharmaceuticals	142.3
4	Ceramics tiles	68.2	17	Plastic	440.2
5	Dairy	449.2	18	Plywood	50
6	Feed/ hatchery	184.7	19	Poultry	136.4
7	Food products	146.5	20	Printing press	80.3
8	Herbs	99.4	21	Rubber roller	161.5
9	Hume pipe	111.1	22	Shoes	325.6
10	Lubricants oil	33.3	23	Soap	269.2
11	Meat	662.5	24	Textile	629.7
12	Metal works	407.7	25	Wood	120.8

Some of the immediate possible measures might be using water-smart technologies to reduce the demand, water reuse, rainwater use, development of a reliable surface source of water, etc. Better waste management is required to ensure the quality of water bodies and rivers. In some states of India, rooftop rainwater harvesting is already made compulsory for newly constructed buildings. The Karnataka state government has proposed 5%to 10% off on water bills for buildings that install rainwater harvest system. Likewise, Delhi government instructed all its departments, local bodies and public sector organizations to install rainwater harvesting systems in their buildings (Arfanuzzaman & Rahman, 2017).

Conclusions and recommendations

Many industries are established in urban areas of Kathmandu valley and this might have also contributed to increased water demand in the valley. Groundwater is the major source of freshwater for industrial use besides other alternative sources such as tanker water supply, industrial district water supply, etc. The higher water use coefficient of beverage industry implied high water

demand for the material production by beverage industry. An average water demand for other industries is nearly 4 to 5 times higher than for a single beverage industry.

Therefore it is recommended that for the sustainable industrial water demand and supply management wastewater treatment and its use, rainwater harvesting and groundwater recharge from rainwater, and efficient water use and water saving technologies should also be adopted and practiced.

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Assessment of Heavy Metals in Landfill leachate: A case study of Sisdol landfill site, Okharpauwa, Nuwakot

Kishor Kumar Maharjan[1*] and Praveen Kumar Regmi[2]
[1*]Asst. Prof. and HOD, Department of Environmental Science,
Tri-Chandra Multiple Campus, Tribhuvan University, Nepal
[2]Faculty, Department of Environmental Science, Tri-Chandra Multiple Campus,
Tribhuvan University, Nepal
*Corresponding address: env.kishor@gmail.com

Abstract

The study is focused on the assessment of heavy metals in leachate of Sisdol landfill site and examine whether the leachate discharged from landfill site does comply with generic standards for industrial effluents set by Nepal government and landfill leachate discharge standards of Indian government. Leachate samples collected during March 2018 from different points of landfill site were mixed to make a composite sample and subjected to analysis for heavy metals such as Arsenic, Lead, Cadmium, Chromium, Copper, Nickel and Zinc. Result showed that some heavy metals like Lead and Chromium exceeded tolerance Limits for industrial effluents to be discharged into Inland surface water set by Nepal Government and Lead exceeded Indian landfill leachate discharge standards. From this study, it is suspected that hazardous waste including electronic waste could have been disposed in the landfill site.

Keywords: *Leachate, Heavy metals, Leachate standards*

Introduction

Leachate may be defined as liquid that has percolated through solid waste and has extracted dissolved or suspended materials. In most landfill, leachate is composed of the liquid that has entered the landfill from external sources, such as surface drainage, rainfall, ground water and liquid produced from the decomposition of the wastes (Tchobanglous et al., 1993).

Landfill leachate is generally a dark coloured liquid with a strong smell and contains high organic and inorganic load. One of its characteristic features is an aqueous solution in which four groups of pollutants are present: dissolved organic matter(volatile fatty acid and more refractory organic matter such as humic substances), more inorganic compounds(Calcium, Magnesium, Sodium, Potassium, Ammonium ion, Iron, Manganese and bicarbonate ions), Heavy metals (Cadmium, Chromium, Copper, Lead, Nickel, Zinc) and xenobiotic organic compounds originating from chemical and domestic residue present at low concentrations(aromatic hydrocarbons, phenols, pesticides etc.) (Christensen and Kjeldsen, 1991).

One of the most hazardous components in leachate is heavy metals. Different kinds of wastes are responsible for the presence of heavy metals in the landfills.Sources such as electronic waste, painting waste and used batteries increase heavy metals content in landfills (Adeolu et al. 2011).

Leachate management has become increasingly complex due to the increase in human population, industrial and technological development. Huge volume of solid waste produces huge amount of leachate produced in landfill site. The landfill leachate creates the potential to deteriorate the water quality of surface and ground water and threaten the aquatic life including human beings. Landfills have been identified as one of the major threats to groundwater resources (Fatta et al. 1999).

Landfill leachate effluent has to comply with discharge standards. However, there is no legislated leachate discharge standard in Nepal. There is the provision of Generic standard for different industrial Effluents to be discharged into Inland surface water. The main objective of the study is to find out whether the leachate discharged from landfill site does comply with generic standards for industrial effluents to be discharged into Inland surface water set by Nepal government and landfill leachate discharge standards of Indian government.

Materials and Methods

Study Area:

Sisdol Landfill site : Sisdol landfill site is a semi-aerobic landfill site that has been constructed at Sisdol in Nuwakot. This landfill site started operating on June 5, 2005, supported by JICA. The site is well connected to Kathmandu with distance of 29 km from existing waste transfer station at Teku. Currently Solid waste from Kathmandu and Lalitpur Metropolitan City and is being managed at the landfill. The total site area is 15 ha and actual landfill area covers 2 ha. The landfill site has two valleys, named as Valley I and Valley II. The area of valley I is 11200 m2 with a volume capacity of 166085 m3 and that of second valley is 9501 m2 with the volume capacity 108910 m3 (Sisdol Landfill Office, Information Center). At present, solid waste are disposed on extension part of valley I site. The leachate treatment system does not work at present and it is in worse condition. The leachate is flowing directly into KolpuKhola(river).

Sampling

The sampling was done in March 2018. Three different sites were selected from currently operated landfill site for sample collection. The samples were mixed to make a composite sample. The composite sample was collected in rinsed sample bottle and then transported to the laboratory of Nepal Environmental and Scientific Services (P) Ltd for analysis.

Seven heavy metals such as Arsenic, Lead, Cadmium, Chromium, Copper, Nickel and Zinc were analyzed in lab following standards methods (APHA, 1998)

Result and Discussion

Heavy metal pollution has raised serious environmental concerns worldwide because bio-accumulation of these elements beyond the tolerance thresholds of living organisms pose long term risk to the earth's ecosystem (Voegelin et al., 2003; Sparks, 2005).

Landfill leachate effluent has to comply with discharge standards. However, there is no legislated leachate discharge standard in Nepal. So, landfill leachate in this study is compared to Generic

standards/Tolerance Limits for industrial Effluents to be discharged into Inland surface water and Indian landfill leachate standards.

Table No. 1: Results of Heavy metals analysis of Leachate

S.N.	Parameters	Test Methods	Observed Concentration (mg/L)	Tolerance limits for Industrial Effluents to be discharged into Inland surface water, (mg/L) (Nepalese Standards)	Permissible Limits of Landfill leachate for Inland surface water, (mg/L) (Indian Standards)
1	Arsenic	SDDC, 3500-As, C:APHA,1998	N.D (0.01)	0.2	0.2
2	Lead	Direct Air-Acetylene ASS, 3111B, APHA,1998	**0.43**	0.1	0.1
3	Cadmium		0.02	2	2
4	Chromium		**0.32**	0.1	2
5	Copper		0.92	3	3
6	Nickel		0.36	3	3
7	Zinc		3.45	5	5

The level of Arsenic concentration was not detected in leachate sample, i.e it is less than 0.01 mg/L. The concentration of Lead was found to be 0.43 mg/L which exceeded both standards (Table no. 1). The presence of Lead in leachate indicates the disposal of lead batteries, leaded paints, plastics etc in the landfill.The concentration of Cadmium (0.02 mg/L), Copper (0.92 mg/L), Nickel (0.36 mg/L) and Zinc (3.45 mg/L) were within the tolerance limits. Cadmium is widely used in rechargeable battery, for production of special alloys. The Copper and Nickel are widely used by man for different purposes such as manufacture of cleaning products, and are contained in cosmetics and shampoos, paints, and lubricants. These sources contribute heavy metals to landfill leachate. The Chromium concentration was found to be 0.32 mg/L which exceeded Nepalese standard (Table no. 1).The concentration of Zinc was found to be within the standards. Although, zinc is an essential trace metal for aquatic life, but when supply in higher concentration, it becomes toxic. The presence of high concentration of Zinc (3.45 mg/L) in leachate may be due to waste materials connected with paint pigments, steel products, roofing, packaging materials (Alloway, 2005), cleaning and food products (European commission 2001).

Heavy metals enhance the overall toxic effect on organisms even at very low concentrations. High levels of metals in the environment could be a hazard for functions of natural ecosystems and human health, due to their toxic effects, long persistence, bioaccumulative properties, and biomagnification in the food chain.

Conclusion

The order of heavy metals concentration found inleachate of Sisdol landfill site were found as Zinc>Copper>Lead>Nickel>Chromium>Cadmium>Arsenic from highest concentration to lowest concentration.

The results from heavy metal analysis showed that, out of seven heavy metals, the concentration of two heavy metals Lead and Chromium exceeded the Nepalese tolerance limit for industrial effluents to be discharged into inland surface water and one heavy metal i.e. Lead exceeded Indian Landfill leachate discharge standard.

Recommendation

Since Sisdol landfill site is expected to be contaminated by hazardous waste so it is highly recommended that concerned authority should carry out proper treatment of the raw leachate before they can be safely discharged into water bodies or in any kind of environment and flow of leachate should be well diverted to leachate pond.

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Mercury and its Health Impact: A Review of the Literature

Upendra K.C.[1*], Swasti Shrestha[2]
[1]Ministry of Health and Population, Ramshahpath, Kathmandu, Nepal
[2]Department of Environment, Ministry of Forests and Environment, Kathmandu, Nepal
*Corresponding address: upen.ggm@gmail.com

Abstract

Mercury (Hg) is a toxic heavy metal that is dispersed throughout the environment and is present in different forms (i.e. paints, pesticides, fungicides, fossil fuels etc.). Among the various sources, the Hg containing devices used in the health care facilities are one of the main sources of mercury through which it is released into the environment. The symptoms of Hg poisoning in human health include kidney damage, disruption of the nervous system, damage to brain function, allergic reactions, deficits during fetal development as well as developmental delays during childhood. So, as a precautionary measure, Government of Nepal had set maximum Hg concentration limit in drinking water, i.e. 0.001 mg/L and beyond this limit water is not regarded safe for drinking purpose. Globally, consciousness against Hg impacts has given rise to Minamata convention in order to protect human health and environment from the harmful effects of mercury. This paper reviews the use of mercury in health sector, its impacts on human health and policies related to mercury in Nepal.

Keywords: *Health Impact; Mercury; Minamata; Policy; Standards.*

Abbreviations

$	Dollar
%	Percentage
<	Less than
°C	Degree Celsius
CEPHED	Centre for Public Health and Environmental Development
etc.	et cetera
FY	Fiscal Year
GoN	Government of Nepal
HCFs	Health Care Facilities
HCWMG	Health Care Waste Management Guideline
Hg	Mercury
Kg	Kilogram
max	Maximum
mg/kg	Milligram per kilogram
mg/L	milligram per liter
mg/m3	Milligram per meter cube
MoHP	Ministry of Health and Population
ppm	Parts per million
UNEP	United Nation Environment Programme

USD	United States Dollar
WHO	World Health Organization
µg/L	micro gram per liter

Introduction

Mercury (Hg) which occurs naturally is a toxic heavy metal (Pandey et al. 2012) found throughout the environment (water, soil, air) and it exists basically in three forms viz. elemental/metallic mercury, organic mercury and inorganic mercury (Mostafalou and Abdollahi, 2013). Metallic mercury is the pure form of mercury that looks like silvery-white liquid which can neither be created nor destroyed (Weinberg, 2010). Regarding its general features, mercury is the 80th element of the periodic table (Bjorklund, et al., 2017) with its atomic weight 200.59, melting point -38.87°C and boiling point 356.58°C (Weinberg, 2010). As compared to other metals, it is a poor conductor of heat, but a fair conductor of electricity. Mercury easily vaporizes and may stay in the atmosphere for up to a year (Rustagi and Singh, 2010). Naturally, it is present in fossil fuels, other minerals and in deposits at Earth crust mostly as cinnabar (Weinberg, 2010). Besides, it is being used by the humans in paints, pesticides, fungicides (Bill, et al., 2008) as well as in various electronic devices (batteries, fluorescent bulbs)/ auto parts and medical products (thermometers and thermostats) (Rustagi and Singh, 2010). Along with this, the use of mercury

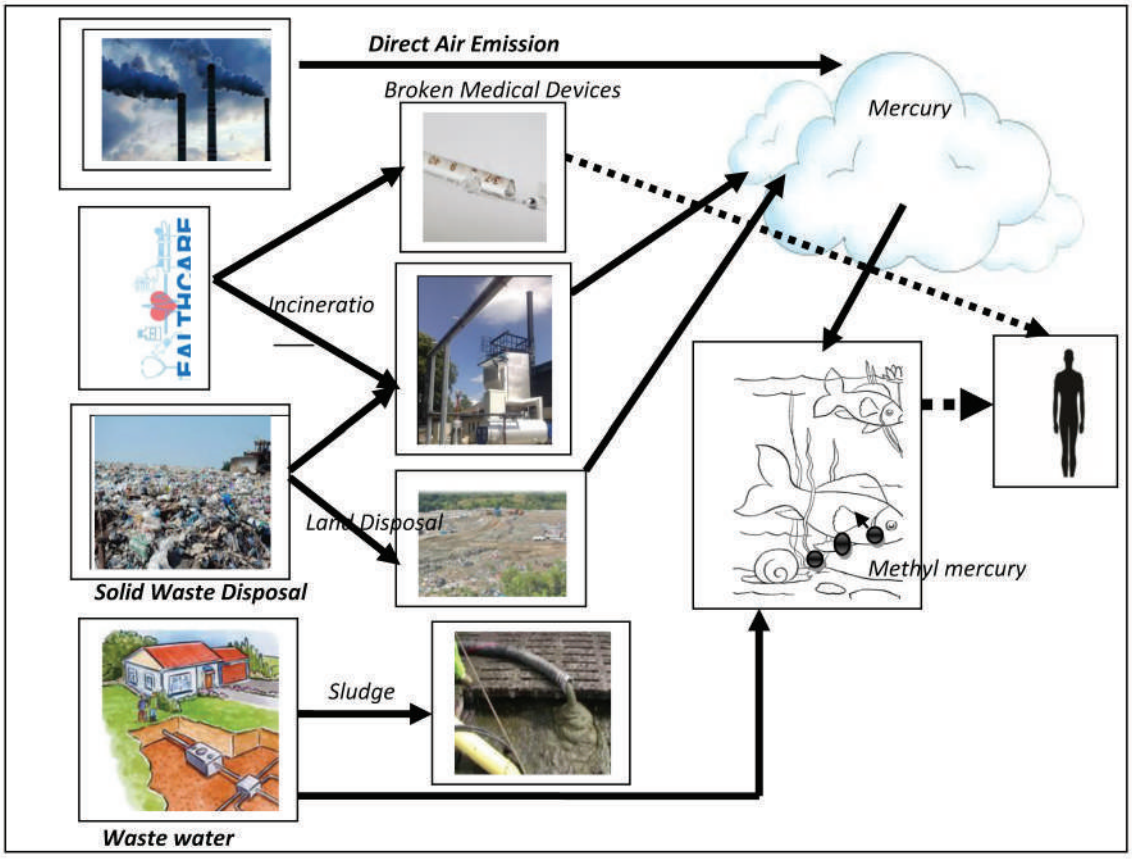

Figure: Release of mercury (Hg) and its transfer from various sources to the human body.

has been largely occurred in various industries as well. In case of such manufacturing entities, the largest consumer of Hg is chlor-alkali industry; second largest consumption is in the production of electric apparatuses and agriculture industry is the third largest consumer (Rani, et al., 2012). It causes allergic reaction and can be genetically regulated (Jain, et al., 2013) as well. When released into the air, it is transported and deposited throughout the globe. However, mercury finally gets deposited at the bottom of the water bodies, where it is transformed into more toxic organic form, methyl mercury (CH3Hg) which then accumulates in fish tissues (Rustagi and Singh, 2010). Since, fish is the major dietary for human and also is the single largest source of Hg; it accumulates substantial concentration of Hg in their tissues (Pandey, et al., 2012). The objective of the study is to to review relevant literatures regarding use of mercury in health sector and its impacts on human health and to review related legislation regarding mercury and recommend necessary actions.

Materials and Methods

The available literature which is in the form of the research reports, journals, articles, newspapers, thesis, books as well as published and unpublished materials through web-based online system have been reviewed for the study. For this paper personal experience is also a key source.

Review of literature

Use of mercury in health sector

Nearly half of the mercury released into the atmosphere is human generated and health care contributes substantial part to it (Rustagi and Singh, 2010). Health-care facilities has become one of the main sources of mercury release into the atmosphere because of use of thermometers, blood pressure gauge (sphygmomanometers), dental amalgam, gastrointestinal tubes, esophageal dilator, laboratory chemicals, pharmaceutical products, electrical appliances etc., as well as emissions from the incineration of medical waste, open burning, burning in barrels, gasification and pyrolysis (WHO, 2005; Factsheet 2011). This fact is also proven by many countries such as Armenia, Cameroon, Ghana, Honduras, Pakistan and Peru as these nations have recognized that thermometers, dental amalgam and waste from hospital releases mercury into the environment (WHO, 2005). Regarding the use of mercury in thermometers, although thermometers contain the smallest amount of mercury per unit compared to other medical devices, they probably represent the largest overall use due to their relatively high sales (Factsheet 2006). Similarly, sphygmomanometers are widely used in hospitals and in private medical practices. Of all mercury instrumentation used in health care, the largest amount of mercury is used in sphygmomanometers (80-100 g/unit). Along with this, dental amalgam which is widely used as dental filling has known to contribute largely to total mercury emission as is shown by a study in the United Kingdom. According to a report submitted to OSPAR Commission (Convention for the Protection of Marine Environments of North East Atlantic), in the UK, mercury contained in dental amalgam and in laboratory and medical devices accounts for about 53% of the total mercury emissions (Rustagi and Singh, 2010). Not only this, the incineration of medical waste has also been a source for mercury release from a long time which is supported by the US EPA report, 1997. It has illustrated that the medical waste incinerators were responsible for as much as 10% mercury release in the air in the US. The hazardous effects of mercury from medical devices occur when these

instruments are either broken or disposed improperly exposing the risks to staff, patients and nearby community.

In Nepal, health care sector is the major consumer of mercury where 501.75 kg of mercury has been used in thermometer and sphygmomanometer. Meanwhile in the hospitals, thermometer breakage rate ranged from 0.48 to 3.44 per bed per year (CEPHED, 2010). In spite of this, there is some good news. The national newspaper The Himalayan Times dated 04th November 2009 had published that National Kidney Centre, Kathmandu is the first mercury-free health centre in Nepal.

Health impacts of mercury

The mercury once released into the atmosphere can remain there for a long time which causes both acute and chronic poisoning (Rustagi and Singh, 2010). It is also considered as a silent threat to the environment (Rahimzadeh, et al., 2014) that has a various toxic effects on the human health which includes; disruption of the nervous system, damage to brain function, spinal cord, allergic reactions, birth defects, development of children, miss carriages, kidney damage and several other severe disorders which may lead to the death (Pandey, et al., 2012; HCWMG, 2014). In addition, the news published on The Kathmandu Post (2013) reveals that according to the World Health Organization mercury causes harmful effects to digestive system, respiratory system and has other effects like; impaired vision/hearing, paralysis, insomnia and emotional instability. Everyone are in high risk of mercury but the dentist and dental nurses who works with amalgam are exposed to higher mercury concentrations than the average population (Aaseth, et al., 2018). Dental sector is also a potential source for mercury as it is used as dental amalgam, which is in fact a compound of mercury (43-54%) combined with other metals including silver, copper and tin. As these filings give mercury vapors, they may pose chronic mercury poisoning. However, any mercury from the fillings swallowed is very poorly absorbed and does not enter the bloodstream (Factsheet, 2011).

Mercury poisoning cases have been reported in many parts of the world, resulting in many deaths every year (Rahimzadeh, et al., 2014). During 1950s, due to having methyl mercury contaminated fish and shellfish by the local inhabitants of Minamata city of Japan thousand of cases of poisoning was reported (Mostafalou and Abdollahi, 2013). In Iraq in 1956, 14 people were dead after eating mercury poisoning wheat (Jalili and Abbasi, 1961). Two decades later during 1970s in Iraq, mistakenly mercury treated seed grain were used for making bread which caused 400 deaths (Mostafalou and Abdollahi, 2013; Grandjean, et al., 2010). In Nepal the research done by Ram Charitra Shah of Centre for Public Health and Environmental Development (CEPHED, 2017) concluded that annual financial losses due to mercury pollution for a small community near Phewa Lake, Pokhara, Kaski Nepal range from $37,600 USD (NRs. 38, 35,200) to $572000 USD (NRs. 5,83,44,000) where mercury pollution originated from a variety of sources including mercury contaminated medical waste, agricultural runoff etc. and reached to the lake water, built up into the food chain and ultimately affect the dependent fisher folks and nearby community.

Global actions on limiting mercury use and its alternatives

Realizing the detrimental effects of mercury use to human health, various nations throughout the

globe have banned their use successively (WHO, 2005). Regarding the regulation on national level, Sweden had banned the use of mercury thermometers back in 1991 and other mercury containing medical devices along with export, sale and import of such devices in consecutive years. Similarly, Denmark banned the sale of mercury products since 1994 whereas France, Norway and the Netherlands imposed ban on the mercury thermometers near to the start of 20th century (Rustagi and Singh, 2010). Also, Norway and Sweden are the one who has banned dental amalgam and in other industrial countries, the use of the filling material is about to be phased out (Aaseth, et al., 2018). The ban on mercury containing devices was banned from various other countries simultaneously as well. European Union (EU) had banned the use of mercury thermometers from 2008. Along with this, several other nations such as Argentina, Phillipines, Uruguay, Taiwan had banned the use of mercury based medical devices by 2010. In case of India, the ban on mercury based medical devices started from Delhi. The issue of mercury was picked up in 2004 which further gained momentum in 2007 when a central government agency order was passed for the phase out of health care based mercury containing devices (Toxics Link, 2011). As like in the health care sector, mercury has already been phased out successfully in chlorine alkali industry (Kim, et al., 2016) as well.

Various alternatives to mercury bearing medical devices have been made. For instance to replace the traditional mercury thermometers, there are electric, electronic or glass thermometers (Factsheet, 2006). Also, regarding the sphygmomanometers, aneroid sphygmomanometers as like the mercury ones have been in use for about 100 years and give accurate results (Factsheet, 2006). Similarly, bougie tubes, cantor tubes, miller abbott tubes and feeding tubes are proposed as alternatives for mercury containing gastro-intestinal tubes (Factsheet, 2011). Regarding mercury containing laboratory chemicals and pharmaceutical, mercury free reagents and preservatives can be used. Likewise in case of dental amalgam, as an alternative to this, non-mercury alternatives such as metal, ceramic, crown, glass, gold and others are available. However, some alternatives are beyond the reach of common people as well (Factsheet, 2011).

GoN policies on mercury: Government of Nepal has banned on import, storage, sale, distribution, production of mercury containing toys beyond the prescribed standards which is 60 ppm and 60 mg/kg (Kathmandu Post 2017). The concerned importer will be required to possess the lab report issued by the certified laboratory of the concerned country in the case of imported toys, while in the case of the manufactured within the country the toys should be tested by the certified lab of the Government of Nepal (The Himalayan Times 2017). Government of Nepal has recently banned the purchase and use of mercury containing devices in all the HCFs (HCWMG 2014). This decision will be helpful to make mercury free HCFs by using mercury free alternative devices.

The standards set for mercury by Government of Nepal, is as follows:-

For drinking water the maximum concentration limit for mercury is 0.001 mg/L (NDWQS 2062). The mercury containing water above this standard is not drinkable or is not safe for the health. And in aquaculture and livestock watering the limit for mercury is <1µg/L and <10µg/L (Nepal Gazette 2008) respectively. In addition, Government of Nepal had banned pesticides called Orano

Mercury Fungicides in Nepal (Source: Environment Statistics of Nepal; 2013).

Tolerance Limits for Different Industrial Effluents Discharged into Inland Surface Water

Characteristics	Land surface water	Public sewerage	Inland surface water
Mercury (as Hg) mg/L max	0.01	0.01	0.01

(Source: Nepal Gazette 2001 and 2003)

Nepal water quality guidelines for the protection of aquatic ecosystem

Parameter name	Target water quality range	Chronic effect value	Acute effect value
Mercury (as Hg) **µg**/L	<0.04	0.08	1.7

(Source: Nepal Gazette 2008)

Emission guidelines for hospital/medical/infectious waste by Incinerator pollutant

Pollutant	Small	Medium	Large
Mercury	0.55mg/m^3 or	0.55mg/m^3 or	0.55mg/m^3 or
	85% reduction	85% reduction	85% reduction

(Source: Environment Statistics of Nepal; 2013)

Minamata convention

The Minamata convention on mercury is a comprehensive international effort to manage and control mercury on a global scale (Bank, et al., 2014). The Minamata convention on mercury was opened for signatory on 10-11 October 2013 (Bank, et al., 2014) and came into force from August 2017 (Basu, 2018; Selin, et al. 2018) where around 140 countries agreed to ban production, export and import of a range of mercury containing products by 2020 to protect human lives and the environment from mercury pollution (The Kathmandu Post, 2013).

The objective of Minamata convention is to protect human health and environment from the anthropogenic emission and releases of mercury and mercury compounds (Hilson, et al., 2018; Lennett and Gutierrez, 2014). It was named after the neurological syndrome caused by severe mercury poisoning from consumption of contaminated seafood known as "Minamata disease" (Mackey et al. 2014). The convention has also set a phase-down approach to dental amalgam through best management practice (FDI, 2014). Furthermore, particularly for developing countries, Minamata convention includes provisions of providing technical assistance and capacity building (Evers, et al., 2016). Nepal is also a member of Minamata convention; the Kathmandu Post on dated (2013) published that Government of Nepal had signed the Minamata convention on Mercury on Thursday 10th October 2013.

Conclusion and Recommendation

Mercury is a toxic heavy metal and is used in various sectors; among which health sector is the one. The instruments like thermometers, blood pressure gauge and pharmaceutical products used

in the health sector are considered as the main source for release of mercury into the environment. Nowadays, the impact of mercury to the human health has become a global concern due to the various chronic and acute impacts of mercury to human health. In many developing countries, mercury is still a big problem which requires urgent action for proper control (Kim, et al., 2016). Because of this, throughout the globe in the health sector, mercury containing devices are being replaced by the mercury free devices. In Nepal too, for addressing this issue, the Government has banned the purchase and use of mercury containing devices in the health sector which is a good step but is not enough in itself. Hence, in order to make the health institutes entirely free from mercury, the professionals should restrict the use of mercury and the Government of Nepal should also conduct regular monitoring and advocacy on its use.

- Continuous research on mercury and its health impact should be conducted from Government and private sector.
- Regular monitoring should be done from the Government side for the effective implementation of the standards and regulation regarding to mercury.
- Awareness in community and school level regarding health impacts of mercury should be conducted.

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Comparison of Particulate Matter between Major Urban and Construction Area of the Kathmandu Valley

Sarina Khanal[1*], Sunil Babu Khatry[2] Amrita Angdembe[3] Abhishesh Nepal[4]
[1] Sarina Khanal, College of Applied Science, Tribhuvan University, Nepal
[2]Sunil Babu Khatry, Associate Professor, College of Applied Science, T.U.
[3] Amrita Angdembe, College of Applied Science, Tribhuvan University, Nepal
[4] Abhishesh Nepal, College of Applied Science, Tribhuvan University, Nepal
*Corresponding address: Khanalsarina11@gmail.com

Abstract

Particulate matter pollution has emerged as a potential threat to the residents of Kathmandu Valley largely contributed by growing population, urbanization, and increasing industrial and vehicular emissions leading to visibility impairment. Visibility is affected by pollutant concentrations, the viewing angle, relative humidity, cloud characteristic, and other physical factor such as color contrast between objects. Residents of Kathmandu valley have been suffering from the hardship caused due to lack of adequate and safe drinking water for a long time. The Government started Melamchi Water Supply Project in December 2000 from PID construction activities (670km) to solve the chronic drinking water shortage in valley on a sustainable manner. Particulate pollution at Comprised of TSP, PM10, and PM2.5 were studied using low volume air sampler for 24 hours duration at New Baneshwor and Gwarko. Particulate pollution at both locations was significantly higher than prescribed NAAQS limits and Visibility Impairment was found higher in Gwarko area. The study discusses on the result of the finding of Particulate Matter and Visibility Impairment in Kathmandu Valley prescribes recommendation for proper management.

Keywords: *PM10, PM2.5, TSP, Visibility Impairment, Air pollution*

Abbreviations

DNI	Distribution Network Improvement
ICIMOD	International Centre for Integrated Mountain Development
KUKL	Kathmandu Upatyaka Limited
LVAS	Low Volume Air Sampler
MLD	Millions of Liters per Day
MoE	Ministry of Environment
MoEST	Ministry of Environment Science and Technology
MWSDP	Melamchi Water Supply Development Board
NAAQS	National Ambient Air Quality Standard
PID	Project Implementation Direction
PM	Particulate Matter
TSP	Total Suspended Particle
WHO	World Health Organization

Introduction

Nepal is the fastest urbanizing country in South Asia and Kathmandu Valley is the fastest-growing metropolitan area in the region (World Bank, 2012). Air pollution has become a serious environmental concern and a public health risk in Kathmandu Valley, and the combination of the "basin effect" with the lack of much air movement in the Valley, predisposes the region to troubles (Fleming 1970). Visibility is affected by pollutant concentrations, the viewing angle, relative humidity, cloud characteristic, and other physical factor such as color contrast between objects (Patrica Brewer & Tom Moore 2009). Particulate matter less than 2.5 microns (PM2.5) is a key contributor to visibility impairment which often composed of numerous chemical species such as sulfate, nitrate, organic carbon, elemental carbon, and crustal material (USEPA 1993; et al Sisler 1996). The construction work of Melamchi water project, DNI works and other associated reforms in KUKL are expected to appropriately address the above issues (PID, KUKL 2017). The objective of the study is to compare the TSP concentration and Visibility impairment at new Baneshwor and Gwarkho area of Kathmandu, Nepal and identify their sources.

Materials and methods

Study Area

The study areas lie in Province No.3 of Nepal in Kathmandu and Lalitpur District and the study was done in January 2017. As the Kathmandu area is situated in a valley surrounded by significantly higher terrain, air pollution dispersion is often limited. Before monitoring, sites were identified and selected randomly both with heavy dust blowing areas at instance. New Baneshwor lies in 27o41'55.02"N Latitude & 85o20'8.12"E Longitude and Gwarko in front of B&B Hospital lies in 27o39'53.68"N Latitude and 85o19'51.59"E Longitude. The air qualities at the sites were monitored by the operation of specified instruments for twenty-four hour duration. During the monitoring, the secondary data like vehicle flow, general weather pattern and sources were recorded.

Fig. 1: Study Area of New Baneshwor and Gwarkho

Air Quality Monitoring Equipment's and Applied Methods

Low volume Air samplers (LVAS) is standard machine especially designed to stimulate human respiratory system and it separates aerodynamic particles contained in the air at nine different size fractions from >10µm (TSP) down to 0.43 µm sizes, which makes possible the estimates of TSP , PM10 and PM2.5 as required in the study. The use of LVAS is considered important in health impact assessment studies, in that it gives quantitative expression for smaller sized particles which can penetrate deeper in the human lungs.

Standard Equipment used for the measurement of PM and Gaseous pollutants

Monitoring Instrument	: Gravimetric Low Volume Air Sampler (LVAS)
Model	: AN-200
Size Range	: 0.43- > 11
Suction flow rate	: 28.3 lit/min (Particulate matter)

Standard monitoring Methods for TSP, PM10 and PM2.5: Monitoring of the TSP PM10 and PM2.5 has been conducted by following JIS Z 8814 -1981 methods.

Study Variables: The monitoring was conducted for twenty four hour duration in each site for following variables: Air Quality Parameters: TSP, PM10 and PM2.5

$$PM_{10} = 914.06\, x\, VV^{-0.73} + 19.03$$

Monitoring Criteria

In New New Baneshwor area, the monitoring device name Low Volume Air Sampler (Anderson type) was kept in the distance about 2.5m from the road and the height from the ground is 1.5m. Monitoring was started in the day time from 15:45 to 15:45 for 24 hr and the total duration was 1390 minutes. In Gwarko area, the monitoring device name Low Volume Air Sampler (Anderson type) was kept in the distance about 2.5m from the road and the height from the ground is 1.5m. Monitoring was started in the day time from 13:00 to 13:00 for 24 hr and the total duration was 1380 minutes.

Calculations Tools

No specific calculation tools were applied for the particulate matter as the study was based on the real time data type. The horizontal visibility was calculated from statistically significant [r2 = 0.95 between horizontal visibility (within the range 200m- 40km) and PM10] D' Almeida's (1986) equation which was applied for a detailed study on the relationship between horizontal visibility and PM10 levels of mineral dust mass concentration using 11 stations in the Sahara and the Sahelian belt.

Where, PM10 is in µg/m³ and VV is the horizontal visibility (km.).

Data Analysis

The obtained data were related with the standards and the consequences effect will be predicted. The primary and secondary data were tabulated and represented in graphs and chart.

Results and Discussion

Particulate Pollution at New Baneshwor and Gwarko

Table 1: Roadside Ambient Air Quality of New Baneshwor (Particulates)

Particulate Size, (µm)	Weight of Dust (mg)	Percentage Weight Fraction	Cumulative Weight Percentage
PM>10 µm	1.7	6.61	100
7.0 µm to 10 µm	1.8	7.00	93.39
4.7 µm to 7.0 µm	2	7.78	86.38
3.3 µm to 4.7 µm	3.2	12.45	78.60
2.1 µm to 3.3 µm	3.4	13.23	66.15
1.1 µm to 2.1 µm	4.4	17.12	52.92
0.65 µm to 1.1 µm	3.2	12.45	35.80
0.43 µm to 0.65 µm	3.7	14.40	23..35
<0.43 µm	2.3	8.95	8.95
Total	25.7	100.0	0

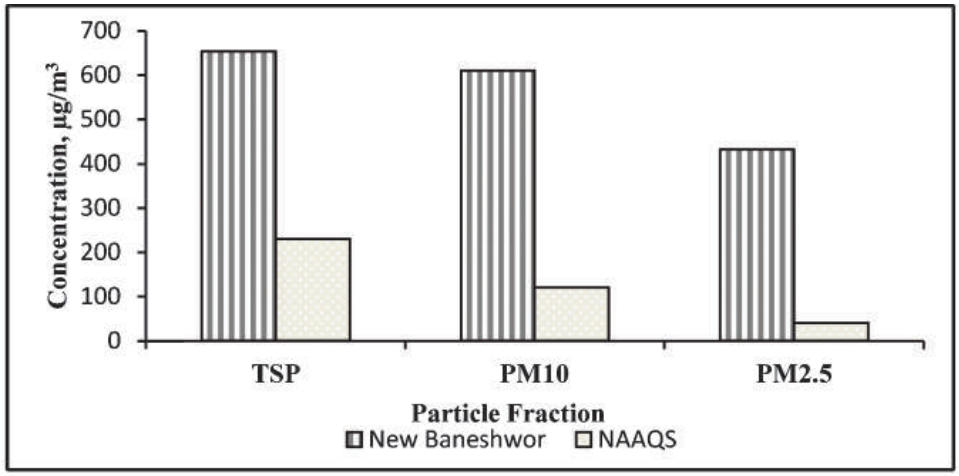

Fig. 2: Comparative Concentration of Particulates, New Baneshwor

Table 2: Roadside Ambient Air Quality of Gwarko (Particulates)

Particulate Size, (µm)	Weight of Dust (mg)	Percentage Weight Fraction	Cumulative Weight Percentage
PM>10 µm	16.8	14.63	100
7.0 µm to 10 µm	3.6	3.14	85.37
4.7 µm to 7.0 µm	4.4	3.83	73.17
3.3 µm to 4.7 µm	4.9	4.27	82.23
2.1 µm to 3.3 µm	5.5	4.79	77.96
1.1 µm to 2.1 µm	28.9	25.17	43.55
0.65 µm to 1.1 µm	21.1	18.38	18.38
0.43 µm to 0.65 µm	16.7	14.55	58.10
<0.43 µm	12.9	11.24	69.34
Total	114.8	100.00	0

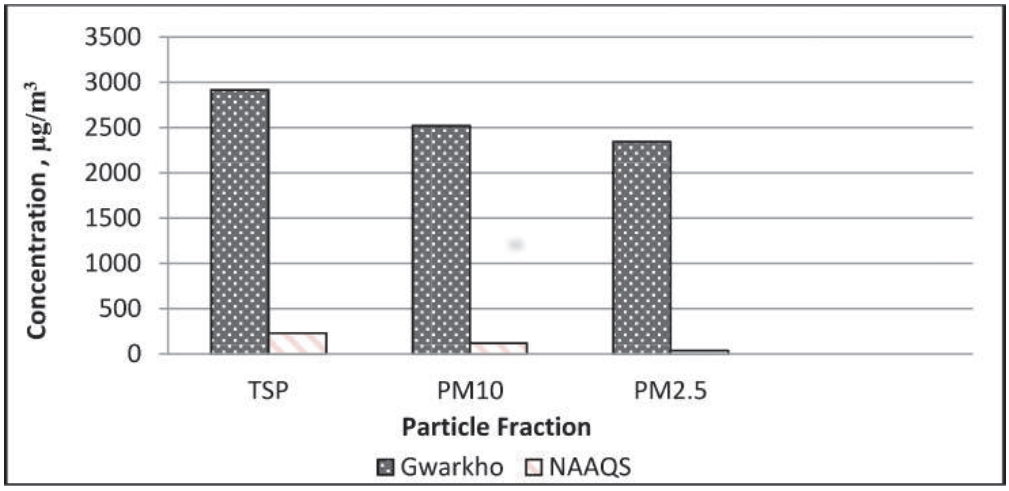

Fig. 3: Comparative Concentration of Particulates, Gwarko

TSP comprised of PM10 and PM2.5 was studied at the study areas. From the observed data, concentration of the TSP at both sites was found higher than national standard (Fig. 2 & 3). The ratio of PM2.5: PM10 is 6:7 at Gwarko and 4:3 at New Baneshwor which indicates PM2.5 is dominating particulate in Gwarko and PM10 in New Baneshwor. None of the monitored parameters complied with the prescribed NAAQS 2012. The observed values for TSP, PM10 and PM2.5 were about 3 times, 5 times and 11 times in Gwarko and in New Baneshwor 13 times, 21 times and 59 times more than the prescribed NAAQS limits. The ratio contribution of fine particles to coarse particles was 0.70 in Gwarko and 0.93 in New Baneshwor. So, the percentage abundance of respirable dust particles in total suspended particulates at the monitoring site was about 93 in Gwarko and 86 in New Baneshwor. The observed values of TSP and PM10 were significantly higher than the measured concentrations at Gautam Budhha Airport construction

site (12 Jan 2016, TSP: 614.16 µg/m³, PM10: 600.16µg/m³, PM2.5: 448.70µg/m³) with the use of slightly moist dust for runway compression activities (GESU 2010).

From the above observation of all monitored parameters Gwarko area were observed higher because the site was located at very dusty ring road pavement and visible air pollution sources were massive, excavated windblown, roadside dust, construction borne dust and occasional traffic jam was noticed at the roadside.

Visibility

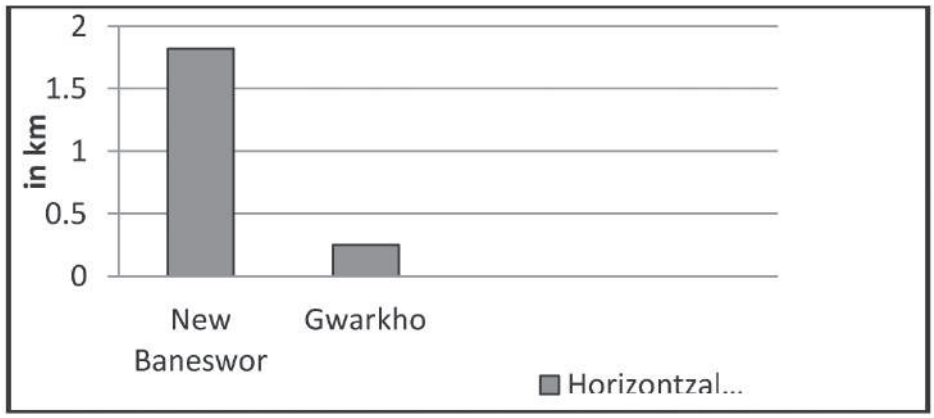

Fig. 4: Horizontal Visibility of New Baneshwor and Gwarko

From the given data horizontal visibility of New Baneshwor area was found up to 1.819 km and of Gwarko area was found up to 0.254 km, and the visibility was found higher in New Baneshwor area than in Gwarko area. In New Baneshwor particulate matter also dispersed in larger area and the visibility impairment is low in that area, while in Gwarko area the value is lower and it disperse in lesser area causing more visibility impairment in that area. Due to higher visibility impairment the atmosphere is too dusty and components of physical environment are not clearly visible due to which their aesthetic value decreases and the accidents in the road increases. Exposure to such area can cause various types of health effects such as, nonfatal heart attacks, irregular heartbeat, and aggravated asthma, decreased lung function (Zhao et al., 2013).

PID Activities

Project Implementation Directorate (PID) of Kathmandu Upatayaka Khanepani Limited (KUKL) was doing ducting work of Melamchi Water Project envisages 510 MLD water to Kathmandu Valley from Sindhupalchowk District As a part of the project, ducting work was completed in New Baneshwor which is inside ring road area .Visible air pollution sources found were smoke from nearby tea stall, dust from the pavement, undergoing constructing house and windblown dust. Gwarko area lies outside the ring road, ring road expansion work has been going on inclusive of PID ducting work, where mud filling is done in its surrounding and it seems more unstable. No dust control mechanisms were applied. The vehicles were drive in dusty road and no any alternative route were used which increase total suspended particle in the environment. Here, the main source of visibility impairment is due to particulate matter in both sites. PM is generated

due to unmanaged work related activities and due to vehicle plying which cause the particulate matter travel to long distance.

Conclusion and recommendation

The observed data clearly indicates that the Particulate concentration TSP, PM10, PM2.5 at Gwarkho site is higher than in New Banewor site. PM10 and PM2.5 are found to be higher than the prescribed limits of NAAQS at both sites and visibility impairment is found greater in Gwarkho site.

Visible air pollution sources found in the study area were smoke from nearby tea stall, dust from the pavement, PID ducting work, undergoing house construction activities, windblown dust and vehicle plying.

Attainment in such area can cause various types of health effects such as, nonfatal heart attacks, irregular heartbeat and aggravated asthma, decreased lung function. In order to maintain the ambient air quality level with prescribed national standards following recommendations are suggested.

- Measures should be undertaken to regulate vehicular emission.
- Dust control measures should be applied during and after construction work.
- Regular monitoring by project proponent and government should be done during and after construction work while carrying out infrastructure development activities.

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Assessing the grazing pressure and resource dependency of Community livelihoods in South- Western section of Shuklaphanta National Park

Tark Raj Joshi
Faculty member, Department of Science and Technology, Far Western University
Corresponding Address:tarkraj2001@gmail.com

Abstract

Buffer zone of Suklaphanta National Park (SNP) leads a heavy pressure into the forest for firewood, fodder, and grazing of livestock and NTFPs. About 87% of the household (HH) depends on the National park for fuel wood and fodder. Local people have seen the park as an attempt by the government to curtail their access to their traditional rights. Present study explores the grazing practices and resource dependency for community livelihoods in South - Western section of SNP. Livestock grazing was one of the serious problems in the study area. Grazing in the reserve was found high in the spring season. A total of 947.6 Livestock Units (LUs) were found grazing inside the Park during the study period. The livestock encroached deeply inside the park thus leading to competition for food between the livestock and the wild animals. The homogeneous distribution of grazing livestock in the sample plots showed that the trench made around the reserve was not effective. Fences were found pressed down in many places. In some places those were completely damaged. Trench was found filled completely with soil and litter. Such conditions of the barriers made easy access to the livestock to enter inside the reserve.

Key Words: *Livelihoods, Resources, Park - People relations, Biodiversity, Grazing pressure.*

Introduction

Prior to the establishment of the Parks & reserves, local people were free to collect firewood, fuelwood, timber, fodder and thatch grass from the forest. Local people were dependent upon it for grazing and fodder for the livestock, bamboo and medicinal plants for their livelihood. With the declaration of Parks & reserve in such areas many people have been legally restrained from using their traditional rights and had no legal rights to procure compensation for their lost benefits (Upreti, 1985). Thus, Parks and reserves are facing sever challenges of conflicts. Many of the conflicts were human origin. They caused severe damage to park resources & jeopardize the accomplishment of set objectives to be met by park administration and management. The restriction imposed on the resources used by the local people to meet their basic need lead to deterioration of the Park-people relation (Shrestha, 2006). Injury by wild animals, poor relation with protection units, illegal fodder collection and lopping of trees, illegal grazing, timber theft, poaching etc are major issues raising the clash between the park and people (UNDP/HMGN, 1994-2001).

Establishment of the protected areas is one of the good steps in the protection, conservation, and maintenance of biodiversity. Protection and conservation of the natural resources with restricting the local people to use the natural resources and damages caused by the wild animals inside the park created negative feelings towards the park. Growing population in the Buffer zone of Suklaphanta National park leads a heavy pressure into the forest for firewood, fodder, and grazing of livestock and NTFPs on the forest, which in those days were their traditional rights to use but

were presently forbidden. Local people have seen the park as an attempt by the government to curtail their access to their traditional rights. Present study explores the grazing practices and resource dependency of community livelihoods in South - Western section of SNP, which is located in Far-western Terai on southwestern edge of Nepal. Despite its several successes in biodiversity conservation, threats to sustainable biodiversity conservation in SNP continue due to some sort of conflicts at different scales. This study aims i) to find out the Status of firewood and fodder utilization and ii) to assess the illegal grazing practices in SNP which have direct concern with the livelihood issues.

Materials and methods

Study Area

The study was conducted during 2007/08 within the buffer zone of SNP. SNP is a protected area in the Terai of the Far-Western Region, Nepal, covering 305 km2 of open grassland, forests, riverbeds and tropical wetlands. In 2017, the status of the protected area was changed to a national park. The park is rich in floral diversity consist of 700 species of flora, including 553 vascular plants, 18 pteridophytes, 410 dicots and 125 monocots. The faunal diversity includes 46 mammal species, 423 bird species, 12 reptiles and amphibian. Major vegetation types are Sal forest, tropical mixed hardwood forest, riverine forest and grassland (https://en.wikipedia.org/wiki/Shuklaphanta_National_Park). The research was carried out in eight different wards (small villages) of Bhimdatta municipality (viz; 13, 14, 15, 18, 19) and Mahakali municipality (viz; 3,4,1), which lie in the buffer zone of SNP along the periphery of forest boundary. The selection of those areas is based on purposive sampling basis.

Socio economic survey

Total 291 HHs , were included for socioeconomic survey. The sample size (n) of the household in the study area was determined by using statistical formula (Arkin and Colton, 1963; cited in Sharma, 2000) at 95% confidence level.

$$n = \frac{NZ^2 \, x \, P(1-P)}{Nd^2 + Z^2 P(1-P)}$$

Where, n = Sample size; N = Total no. of households
Z = Confidence level (at 95% level Z = 1.96)
P = Estimated population proportion (0.05, this maximize the sample size)
d = Error limit of 5% (0.05)
Set of questionnaire were used to collect the data on extent of, livestock depredation, livestock rearing and grazing, and resource extraction. The survey was conducted by direct interview with household interview using structured and semi –structured questionnaire with some close ended and some open ended questions. The HHs survey was validated by focus group discussion (FGD), direct observation and key informant interview.

Assessment of Livestock Grazing

To count the livestock grazing, 100 m trench was measured and marked in each 2 Km trench interval. Ten such plots were taken from the Reserve Headquarter, Majhgaon to Pipariya (ward-13

of Bhimdatta municipality) near Mahakali River and from Majhgaon to Malumela post (ward-19 of Bhimdatta municipality) near Chaudhara River. In every 100m measurement, 100 meter distance was measured perpendicularly inside the reserve from the trench to count livestock grazing. Counting of livestock was done upto 500 m perpendicularly inside the reserve. The average number of livestock entering into the reserve per day was converted into livestock units (LUs) by following conversion factors (Bride, 1983, Jahnke, 1982: cited in Nakarmi, 1999)

Cattle	Conversion Factor
Buffalo	1
Cow/OX	0.8
Calf	0.4
Goat	0.2

Data Analysis :The quantitative data obtained was analyzed using Statistical package for social science (SPSS -16) and statistical measures ANOVA and Z-test.

Results and discussion

Socio - economic Settings

The total numbers of male respondents surveyed were 63.6 % whereas female respondents were 36.4 %. Among a diverse ethnic community in the vicinity of SWR, Chhetri constituted 38.3 % followed by occupational caste 28.7 %. Those included, Luhar, Kami, Damai and Sarki. Janajatis (Tamang, Magar, Gurung, Newar,Tharus) Consituted about 13.8 %. The Brahmin, Chhetri, Janjatis (except tharus) and occupational caste were all migrants from the hills. Brahmins and Chhetri shows the population dominancy over others.

Table 1: Distribution of HH according to ethnicity

Ethnicity	Total HH	
Brahmin	57	(19.5)
Chhetri	111	(38.3)
Janjati	40	(13.8)
Occupational caste	83	(28.7)
Total	291	(100)

Data in parenthesis are in percentage

Fodder Consumption and its sources

Majority of the HH (93.5%), out of 291 HHs, depends on fire wood as major source of fuel. National Park, Government Managed Forest, Community Forest (CFs) and drifted wood were the major sources of household fuel wood. Majority of the HHs (87 %) seems to depend on SNP for firewood as source of fuel as shown in table 2.

Table 2: Major Source of Firewood & Fodder

Source of firewood & fodder (n=272)	Total HH	Percentage
Wildlife park	236	87.0
Government Managed Forest	1	0.4
Private land	6	2.2
Community Forest	9	3.3
Drifted wood	20	7.3
Total	**272**	**100**

The annual consumption of firewood (FWC) for the sampled household was found to be 9,39,900 kg of firewood and 21,25,440 kg of the fodder respectively. 87 % of household demand for fuel wood was single-handedly by SNP. In average, the fuel wood and fodder consumption per HH was found to be 3,455Kg /HH/ Yr and 7814.11 Kg/HH/Yr respectively. Similarly it was observed that big farm sized HH had higher consumption of fodder than small farm holding. This indicates household with large farm size require high amount of fodder as they have large number of livestock. The statistical analysis (z α, 0.05=9.225) also showed that the proportion of the people using forest products for firewood & forage was not equal.

Table 3: Total amount of firewood consumption

Fire wood consumption (n=291)		
Total HHs using firewood resources	FWC (Kg/yr)	FWC (Kg/HH/Yr)
272 (93.5)	9, 39,900	3,455.5

Data in parenthesis are in percentage

Table 4: Total amount of fodder consumption

Fodder consumption (n=291)		
Total HHs using fodder resources	Fodder consumption (Kg/yr)	Fodder consumption (Kg/HH/yr)
272 (93.5)	21, 25,440	7814.11

Data in parenthesis are in percentage

The major forest products harvested from the Park were - fire wood and fodder. Previous studies (Pande 2000, Joshi 2002) found that most of the HH (92%) used firewood from park. This study also showed that the extraction of fire wood, as a critical problem, still existed at the same rate (93.5%).The main reason for this was due to the absence of Community forest in Buffer Zone area of Park. Generally poor people preferred to collect firewood rather than buying it from the market (Bhatta, 1994) and they have a tendency to exploit nearby forest first than to think of a sustainable use. Not only fodder and firewood but also timber theft was a serious problem over there causing conflict.

Livestock Rearing and Feeding Pattern of Livestock

Livestock played a significant role to have the valuable products such as milk, meat, egg, etc. Most of the HH had unproductive cattle which consequently lead to grazing problem. Among the surveyed HH, people kept - cows, oxen, buffaloes, pigs, goats in their houses. But the numbers of pigs were found to be lower in comparison to the others. It was found that, people fed their livestock in '4' ways. They were 1) Grazing inside the Park 2) Grazing in their own farm 3) Stall feeding 4) Grazing along the river bank. The following table showed the people's view in their feeding pattern of livestock .The ANOVA test statistic, (F 0.05 (3,8) =1.3526) showed that there was significant difference in feeding category of livestock.

Table 5: Ranking on Feeding Pattern of Livestock

Feeding Category	Rank 1	Rank 2	Rank 3
Grazing inside the Park	28	16	13
Grazing in the farm	56	167	9
Stall feeding	181	65	4
Grazing along the river bank	3	4	1

Livestock Grazing Pressure

Livestock grazing was one of the serious problems in the study area. Due to the absence of livestock grazing land near the reserve livestock were found taken inside the reserve. Grazing in the reserve was found high in the spring season. The number of livestock grazing per day in 10 different plots was enumerated.First plot was not considered for analysis because livestock grazing was found to be zero in the first plot during data collection. This might be probably due to presence of reserve headquarter and relatively good condition of barriers like trench and fence in plot number one. The data of 9 plots i.e. from 2ndto 10thplots were converted into LUs and considered for ANOVA test.

Table 6: Average number of livestock units grazing per day in experimental plots

Types of Live-stock	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10
Cow	20.8	81.6	66.4	76	52	40.8	41.6	21.6	40.8
Ox	11.2	78.4	50.4	69.2	47.2	34.4	35.2	31.2	24.8
Calf	1.6	10.4	5.6	5.6	8.4	5.6	6	3.6	2
Buffalo	3	12	10	12	10	4	0	0	2
Goat	0	6.4	2.8	3.4	3.4	1.2	1.6	1	2.4
Total	36.6	188.8	135.2	166.2	121	86	84.4	57.4	72
Mean	7.32	37.76	27.04	33.24	24.2	17.2	16.88	11.48	14.4

The ANOVA test showed that (F 0.05 (8,36) = 0.8425) the number of livestock grazing inside the park per day in each plot did not significantly differ from each other. The homogeneous distribution of livestock in the plots showed that the trench made around the reserve was not effective. This might be due to some imperfections of the barriers.

Conclusion and recommendations

Present study showed that the annual consumption of firewood (FWC) was 9,39,900 kg and 21, 25,440 kg of the fodder respectively. In average, the fuel wood and fodder consumption per HH was found to be 3,455Kg /HH/ Yr and 7814.11 Kg/HH/Yr respectively. The homogeneous distribution of grazing livestock in the sample plots showed that the trench made around the reserve was not effective. Such conditions made easy access to the livestock to enter inside the reserve. According to the Park authority there was no problem of grazing inside the Park but the study showed that illegal grazing of livestock still remained as a major problem. A total of 947.6 LUs were found grazed inside the Park during the study period. The livestock encroached deeply thus leading to competition for food between the livestock and the wild animals and in such situation the conservation efforts may work no more.

Provision of use of alternative energy resource will reduce the pressure of firewood consumption and Stall feeding and adoption of proper grazing management practices could reduce the grazing pressure inside the reserve. It should be realized that protected areas should be viewed as components of larger regional human ecosystems and not as isolated entities.

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Assessment of Indoor Air Pollution and Associated Health Impacts in Households Equipped with and without Biogas: A Case for Amlekhganj

S Shrestha[1*], HS Baral[2]
[1] Central Department of Environmental Science, Tribhuwan University, Kathmandu, Nepal
[2] School of Environmental Sciences, Charles Sturt University, Australia
CorrespondenceAuthor: shresthashrisi02@gmail.com

Abstract

Household's dependency on biomass for cooking and its incomplete combustion creates dangerous cocktail of indoor air pollutants. The study aimed to find concentration of major indoor air pollutants specifically CO, PM2.5and RSPM and associated health impacts due to current energy use. AirVisual's Node, Gravimetric analysis, NDIR Spectrophotometer were used to determine PM2.5, RSPM and CO respectively. Information on energy dependency of households and associated health impacts were obtained through schedule survey, KII and FGD. Emission of biogas in terms of CO and PM2.5 was within limits recommended by national guideline as compared to households without biogas. Positive relation between PM2.5 – CO was observed. Among various parameters that could have impact on indoor air quality, only few parameters were found to be statistically significant. Community members were aware of negative health impact resulting from use of firewood as primary or secondary source of energy whereas biogas was perceived as clean energy source.

Keywords: *CO, Indoor air quality, PM2.5*

Introduction

Air pollution, a single most man-made effect due to poorly regulated energy production and its inefficient combustion is receiving a growing concern for its control (Sinha & Nag 2011). Indoor air pollution as a result of burning traditional energy resources is counted as a serial killer (WHO, 2004) and this reliance is leading to significant health burdens (WHO, 2014). The dependency of half of the globe's population on biomass fuel for cooking and space heating purpose burnt in primeval stoves often associated with inadequately ventilated kitchen is exposing them to hazardous cocktail of pollutants (Bruce et al., 2000). The study aims to find the current energy use practices, concentration of key indoor pollutants PM2.51, CO2 and RSPM3 and health impacts due to current energy. Results from the study can be strong evidence for implementing biogas or other alternative energy for improving indoor air quality and health status.

Materials and Methods

Amlekhgunj village is located at the geographical coordinate of of 27.2961°N, 85.0026°E in Bara district of Province 2 (Figure 1). Study area being located 44km away from district headquarters, Kalaiya in the buffer zone of Parsa National Park. Ward number 1 and 5 were selected for the research purpose (as per old federal system).

A total 140 households were sampled for schedule survey which was determined by Krejcie and Morgan sampling (1970) method. Households were selected by systematic random sampling. Schedule survey revealed information on household energy use, factors that prompt people to use firewood, species of firewood used, kitchen condition etc. The prepared questionnaires were pre tested at the time of pre field visits. Field visit was conducted in April, 2017.

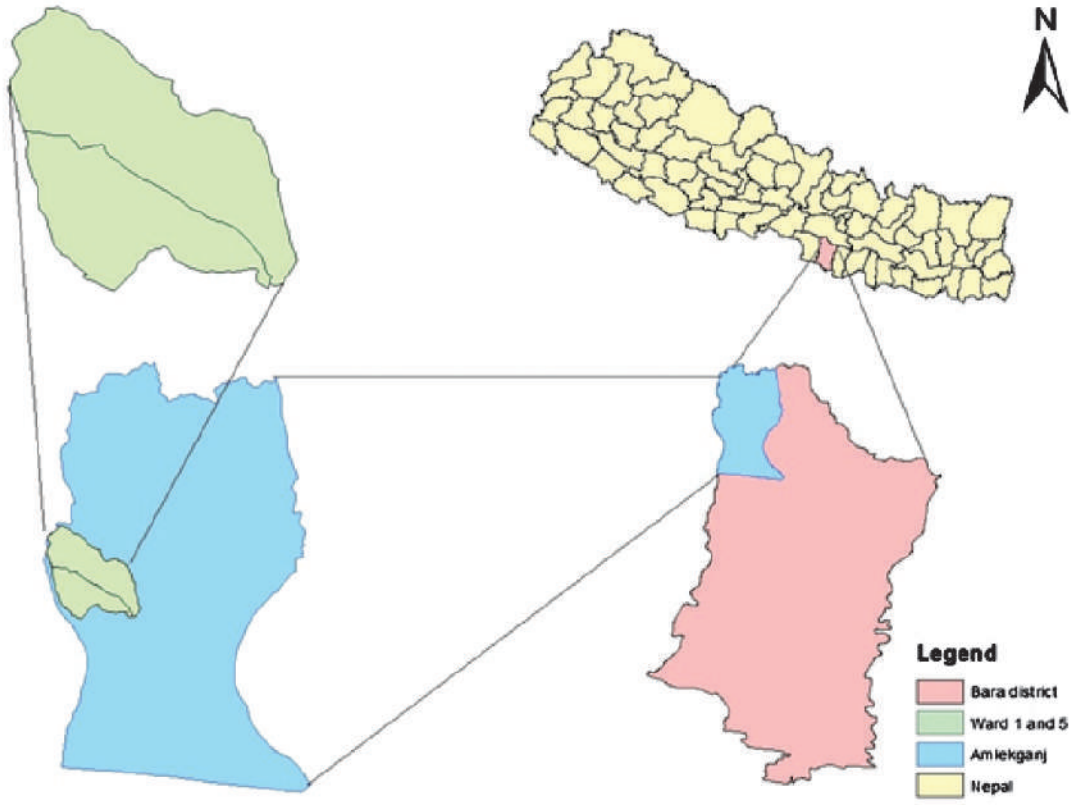

Figure 1.Map of study area

Indoor air pollution was monitored during the cooking time either in the morning or evening time for 1 hour in 19 households (10 non biogas using households and 9 biogas using households) applying the protocol developed by National Indoor Air Quality Standards and Implementation Guidelines, 2009. The target pollutants for study like. PM2.5, CO and RSPM are serious indoor air pollutants which are produced while cooking due to use of various energy sources. Here the non-biogas using households refers to the households that use firewood.

Kitchen concentration of PM2.5 was estimated using AirVisual's new Node device which is based on laser sensor technology. PM2.5 concentration (in µg/m3) was noted at the interval of every 10 seconds and averaged at final. Telegon Combustion Gas Analyzer (Tempest 50) was used to measure concentration of CO. The instrument is based on Nondispersive infrared sensor Spectrophotometer principle. CO level (in ppm) was noted at interval of every 10 seconds and

averaged at final.Instrument was located within 120 cm from the main source of pollution and 120 above the floor (breathing zone). RSPM concentration was measured through gravimetric analysis using Casella Cel Personal air sampler.

Students t test was carried out to determine the whether there was any significant difference in the concentration of PM2.5, CO and RSPM in the households equipped with and without biogas. Also, Pearson's correlation coefficient was calculated to find out the relationship between PM2.5 and CO emissions.

Results and Discussion

Among the 140 respondents interviewed 77.85% were females. A supportive logic, here to explain, why more female respondents were interviewed than males lies in the fact that most respondents were approached in their house where possibility of finding women is greater than men.

a. Household Energy Use

All the three forms of energy sources for cooking viz. traditional, alternative and commercial energy sources found in the country (WECS, 2010) were evidenced in the study area. Table 1 represents the energy use for cooking purpose while figure 2 represents the household's dependency on various sources of energy and exact percentage of household solely dependent on one form of energy or combination of energy sources.

Table 1: Energy use for cooking purpose

S.N	Energy Source	Number of HHs
1	Firewood	109
2	LPG	59
3	Biogas	22
4	Coal	4

Source: Field visit, 2017

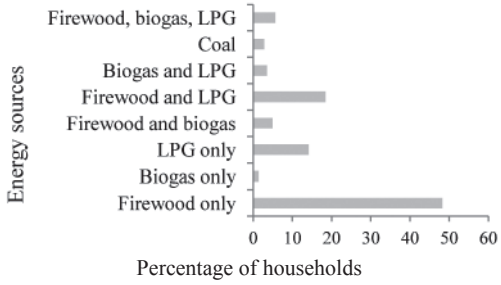

Figure. 2 Household dependency on more than one kind of energy source

Table 1 indicates that a very high number of HHs is dependent on firewood as source of energy, followed by LPG and others. Buffer zone forest namely Sano damar jungle, Bhoti kholadovan, Pakkinaliand Kaminidaha jungle of Parsa National Park acts as lifeline energy source for cooking purpose of the community people. Rules and regulation of the buffer zone allowed community people to collect dried, dead and decayed parts of the trees twice a week. Thus easy access of firewood could be a major reason for high firewood consumption for energy use. Per capita firewood consumption was found to be 1252 kg/ person/ year. Those who were not able to collect firewood when needed used to buy from vendors.

Biogas was the only alternative energy source being used and among the households recorded without biogas 63.58% showed willingness to install biogas plant due to clean indoor air and its benefit of not leaving black stain on cooking utensils.

b. Indoor Air Pollutants

Table 2 summarizes the average concentration of indoor air pollutants in the households equipped with and without biogas.

Table 2: Average concentration of indoor air pollutants in the households equipped with and without biogas.

Parameters	Biogas	Without Biogas
CO (ppm)	9.53	102.1
$PM_{2.5}$ ($\mu g/m^3$)	48.43	135.5
RSPM ($\mu g/m^3$)	194.08	460.16

(Source: Field visit, 2017)

b.i. CO

The average CO concentration ranged from 5.7 ppm to 14.3 ppm in the households with biogas and from 79 ppm to 140 ppm in households without biogas. Average concentration of CO in households with and without biogas was found to be 9.53 ppm and 102.1 ppm respectively. CO concentration was significantly lower in households with biogas (P = 0.000) at 5 % level of significance.

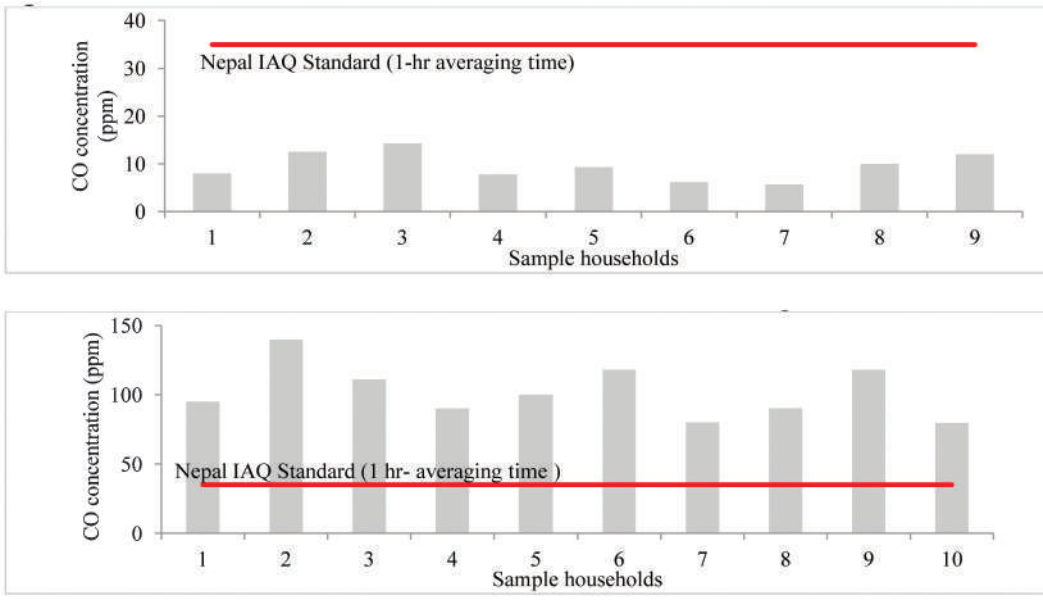

Figure. 4 Average concentration of CO in individual households without biogas

Nepal's National Indoor Air Quality Standard and Implementation Guideline recommend acceptable concentration of CO to be 35 ppm for 1 hour averaging time. All the samples from households with biogas is within the acceptable concentration while samples from households without biogas exceed the acceptable concentration.

b.ii. PM2.5

The average concentration PM2.5 concentration ranged from 30.2 µg/m3 to 64.0 µg/m3 in the households with biogas and from 94.0 µg/m3 to 347.0 µg/m3 in households without biogas.

Average concentration of PM2.5 in households with and without biogas was found to be 48.43 µg/m3 and 135.5 µg/m3 respectively. PM2.5 concentration was significantly lower in households with biogas (P = 0.003) at 5 % level of significance.

Table 3: Average concentration of PM2.5 in the households equipped with and without biogas

S.N	$PM_{2.5}$ Concentration (µg/m^3)	
	Biogas	Without biogas
1	52.12	106.0
2	38.0	347.0
3	64.0	116.0
4	55.9	102.0
5	40.3	123.0
6	30.2	142.0
7	55.0	98.0
8	45.4	110.0
9	55.0	117.0
10		94.0

(Source: Field visit, 2017)

Nepal's National Indoor Air Quality Standard and Implementation Guideline recommend acceptable concentration of PM2.5 to be 100 µg/m3 for 1 hour averaging time. All the samples from households with biogas is within the acceptable concentration while 80% samples from without biogas exceed the acceptable concentration.

b.iii. RSPM

The average concentration RSPM concentration ranged from 92.09µg/m3 to 276.08 µg/m3 in the households with biogas and from 367.17 µg/m3 to 1094.47 µg/m3 in households without biogas. Average concentration of RSPMin households with and without biogas was found to be 194.08 µg/m3 and 460.16 µg/m3 respectively. RSPMconcentration was significantly lower in households with biogas (P = 0.004) at 5 % level of significance.

Table 4: Average concentration of RSPM in the households equipped with and without biogas

S.N	RSPMConcentration (µg/m^3	
	Biogas	Without biogas
1	184.13	368.47
2	181.87	1094.47
3	184.66	368.47
4	274.16	367.17

5	184.66	369.06
6	92.09	553.34
7	184.69	370.12
8	276.08	371.05
9	184.42	368.48
10		370.97

Source: Field visit, 2017

The concentration of CO while burning biogas is comparatively similar to study conducted by McCord (2012) while in burning firewood the concentration is higher than study conducted by Parajuli el al., 2016 and much lower than the study conducted in Gorkha (280 ppm), Beni (310 ppm) (Pandey, 2003). PM2.5 is found to be slightly higher compared to the study conducted McCord (2012) in the households with biogas while in the households without biogas study conducted by Nepal Health Research Council (NHRC) reveals the higher concentration of 8207 µg/m3 in the year 2001 and 2298.01 µg/m3 in the year 2004. Our results show much lower value as compared to study conducted by NHRC. RSPM concentration was found to be significantly higher than the study conducted in Andhra Pradesh as the difference in RSPM concentration can be due to housing and climatic condition affecting indoor concentration (Balakrishnan et al., 2002). The concentration of CO2 in the study area in both households with and without biogas is found to be lower than the study conducted by Bindu& Reddy (2016) in commercial kitchens in India which was found to be 1355.43 ppm.

The concentration of the pollutant while firewood combustion highly depend upon the various factors like species of firewood burnt, condition (dry or wet) of the firewood, ventilation system, family size, quantity of firewood used, kitchen size etc.

c. Correlation Analysis

PM2.5 – CO correlation

Pearson correlation was carried out to determine whether CO could use as a surrogate proxy for PM2.5 in this particular setting or not. PM2.5 – CO correlation in two different cooking types is presented in the table 7.

Table 5: PM2.5 – CO correlation

Cooking Stove	Parameters	$PM_{2.5}$
Biogas	CO	0.307
		P= 0.423
		N= 9
Without Biogas	CO	0.788**
		P= 0.007
		N= 10

***. Significant at 0.01 level of significance* *Source: Field visit, 2017*

CO - PM2.5 correlation carried out in the various setting in various parts of the world reveal that CO - PM2.5 correlation while burning biogas is weak which is also evidenced in study conducted in Rural Cambodia by Busyman (2015) where r = 0.23. While burning firewood correlation ranges from low to high evidenced by r = 0.29 (Alnus et al., 2014),r = 0.59 (Bartington el al., 2016) and r = 0.76 (Northcross et al., 2010). Variation in correlation can be explained by cooking characteristics, fuel type and cooking behavior (Bartington et al., 2016). Various researches also lead to conclusion that household characteristics along with condition of stove primarily influence emission and pollutant dilution which can determine PM and CO relation (Naeher et al., 2001).

Correlation analysis between different parameters

A large number of factors can significantly influence the concentration of indoor air pollutants. Correlation reveals that among the various factors that could impact in indoor air quality, only a few parameters were found to be statistically significant.The correlation of CO and PM2.5 with the factors contributing to indoor air pollutants in households with and without biogas is presented in table 6 and 7.

Table 6: Factors contributing to indoor air pollutants in households with biogas

Parameter	CO	$PM_{2.5}$
Family size	0.769*	0.526
Average time spend in kitchen	0.072	0.144
Ventilation	-0.182	-0.507
Fuel consumption per day	0.330	0.143
Size of the kitchen	-0.619	-0.316

**. Correlation is significant at 0.05 level* *(Source: Field visit, 2017)*

Table 7: Factors contributing to indoor air pollutants in households without biogas

Parameter	CO	$PM_{2.5}$
Family size	0.721*	0.967**
Average time spend in kitchen	0.442	0.171
Ventilation	-0.388	-0.200
Fuel consumption per day	0.723*	0.956**
Size of the kitchen	-0.626	-0.531

**. Correlation is significant at 0.05 level* *(Source: Field visit, 2017)*

***. Correlation is significant at 0.01 level*

d. Health Survey

Health survey was conducted in total 140 households which were based on perception rather than clinical or medical diagnosis. 72 % of the households that were using firewood as a primary or secondary source of energy perceived various health impacts whereas other households that

were using biogas or LPG didn't perceived any major health impacts. The key health problem perceived by most respondentswas eye redness and irritation at the ignition of firewood (55.61%) followed by asthma (16.6%), cough (14.94%) and headache (12.45%).

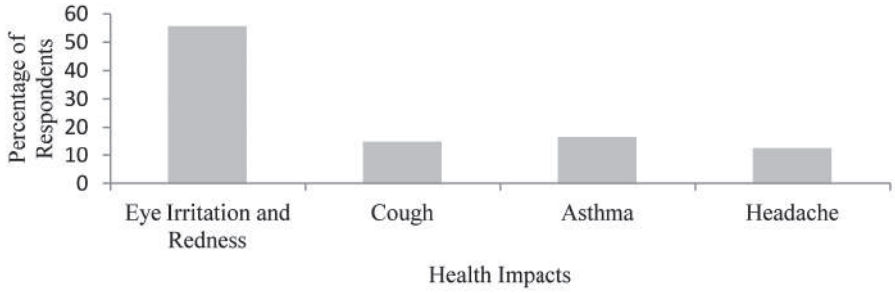

Figure. 5 Health issues related to indoor air pollution

Presence of smoke and exposure to smoke are proved to be hazardous ultimately leading to death (Warwick, 2004). Various studies conducted in the various parts of the world as well as various parts of Nepal provide enough evidence that children and women get exposed to unacceptable level of indoor air pollution during the time of cooking (Lohani, 2011). Major impacts perceived by the respondents are highly linked with indoor air pollution. A study conducted in Palpa has also reported similar impacts on the health due to firewood. The key health problems identified included headache, difficulty in breathing, irritation eyes, chest pain etc. (Parajuli et al., 2016). Respondents in Samagaun VDC also perceived the health problems like eye irritation, cough, asthma and ARI (Suwal, 2013).

Conclusion

Emission from biogas is comparatively safer as compared to emissions from households without biogas. PM2.5 and CO concentration is in safe limit recommended by national guideline while CO exceeds the safe limit in households without biogas. The correlation analysis reveals that CO cannot be used as substitute for PM2.5 and both parameters are equally important to measure. All the factors that can have significant influence on concentration of pollutants like CO and PM2.5 were not statistically significant. Health impact in the households using firewood as primary or secondary source of energy was perceived whereas in case of biogas it was not perceived. Majority of the kitchen drudgery including firewood collection was primary responsibility of women. This practice has increased health impact on the women as compared to other family members. Biogas is a popular alternative energy source. Community is interested towards alternative energy resources; biogas to be specific due to various advantages associated with it. Biogas is hence safe in terms of reduction of indoor air pollutants as well as reducing health hazards.

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Particulate matter pollution in Nepal: Analysis of air quality monitoring station (AQMS) data for the year 2017.

Govinda Prasad lamichhane*, RajeshorPaudel* , Shankar Prasad Paudel*
*Department of Environment, Babarmahal, Kathmandu,Nepal.
Corresponding email:- lamichhanegovin@gmail.com

Abstract

Air pollution has negative impacts on human health and economy. Establishment and operation of air quality monitoring stations is a basis for air quality management program. Government of Nepal is establishing and operating Air quality monitoring stations throughout the country. By the year 2017 eleven monitoring stations came in operation. Each monitoring station measure PM 1, PM2.5, PM10 and Total suspended particulate simultaneously. The data from four air quality monitoring stations was analyzed to calculate daily average and annual average. Compliance with National standard was compared. Lumbini has the highest annual average PM 2.5 value while Ratnapark has the highest annual average value for PM10. The annual average PM 2.5 for Lumbini, Ratnapark, Pulchowk and Dhulikhel is 52.52 µg/m3 , 40.32 µg/m3 , 32.28 µg/m3 and 31.45 µg/m3 respectively. Similarly The annual average PM 10 for Lumbini, Ratnapark, Pulchowk and Dhulikhel is 71.59 µg/m3, 91.49 µg/m3 , 38.73 µg/m3 and 56.34 µg/m3 respectively.

Key words: *air pollution, PM2.5, PM10, Total suspended particulate.*

1. Introduction

Air pollution has negative impact on human health. It has respiratory, cardiovascular, neurological, cancer and other health effects. Air pollution also has economical effects. (Curtis et al 2006). Like many developing countries little research on air pollution has been conducted in Nepal (Gurung and Bell, 2013). Few research has been conducted on air quality of Kathmandu valley in past while little research has been conducted outside Kathmandu valley. High pollution of Kathmandu valley is associated with high prevalence of bronchitis, and throat and chest disease.(Sharma 1997). Motor vehicles, soil dust, biomass/ garbage burning and brick kilns are the major sources of pm 10.(Kim et al, 2015). Rapid growth of industries, high population density and traffic has caused high level of pollution in Kathmandu valley (Giri et al, 2006). To full fill the data gap on air quality research government of Nepal is establishing throughout the country. By the year 2017 Department of environment had established eleven air quality monitoring stations.

National Ambient Air Quality Standard, 2012 (NAAQS).

Nepal Government has set and enforced National ambient air quality standard (NAAQS) and has a legal obligation to maintain this standard. The National ambient air quality standard has set standard for particulate matter with aerodynamic size less than 10 micrometers called PM10, particulate matter with aerodynamic size less than 2.5 micrometers called PM2.5 and total suspended particulate(TSP). The national standard for pm 2.5, PM 10 and total suspended particulate are given below.

Parameters	Units	Averaging time	Concentration max
Total suspended particulate	µg/m^3	24 hrs	230
pM 10	µg/m^3	24 hrs	120
pM 2.5	µg/m^3	24 hrs	40

(Source: NAAQS, 2012).

Similarly World health organization guideline value for PM 2.5 is 10 µg/m3 annual mean and 25 µg/m3 24-hour mean. Similarly guideline value for PM 10 is PM10: 20 µg/m3 annual mean 50 µg/m3 24-hour mean (WHO, 2005).

The main objective of this report is to present the status of air quality based on the data collected from air quality monitoring station run by Department of Environment.

2. Material and Methods

Nepal is a small country with 147,181 square km area and population of 26,494,504. (CBS, 2011). It is politically divide in 7 provinces. The country has subtropical to alpine/ arctic climate. The Capital Kathmandu is also major commercial city of the country.

Government of Nepal has started to establish air quality monitoring station since 2016. By the end of 2017, 11 monitoring stations came into operation whole over the country. Department of Environment is working in coordination with many organizations like ICIMOD in establishment and operation of these monitoring stations. This article has been prepared on the basis of analysis of data from air quality monitoring stations of the year 2017. Each monitoring station has Grimm Electronic Dust Monitor (EDM) 180 to measure particulate matter of different sizes. The instrument measures PM 1, PM 2.5, PM 10 and TSP simultaneously. Since government has not set standard for PM 1 it is not included here. The air quality monitoring stations generate data for every minute. Daily average is calculated if data is available for every minute of a day. Out of those eleven stations four stations has data throughout the year. So data of those four stations is analyzed and compared. Other came in operation only after august 2017.

3. Results and Discussion

3.1. PM 2.5

The annual average PM 2.5 for the four stations was calculated. Lumbini has the highest PM2.5 value of 52.52 µg/m3 with standard deviation 38.99 and Pulchowk has the lowest value of 32.28 µg/m3 with standard deviation 24.19. Similarly annual average PM 2.5 value for Ratnapark is 40.32 µg/m3 with standard deviation 25.20 and that of Dhulikhel is 31.45 µg/m3 with standard deviation of 72.93.

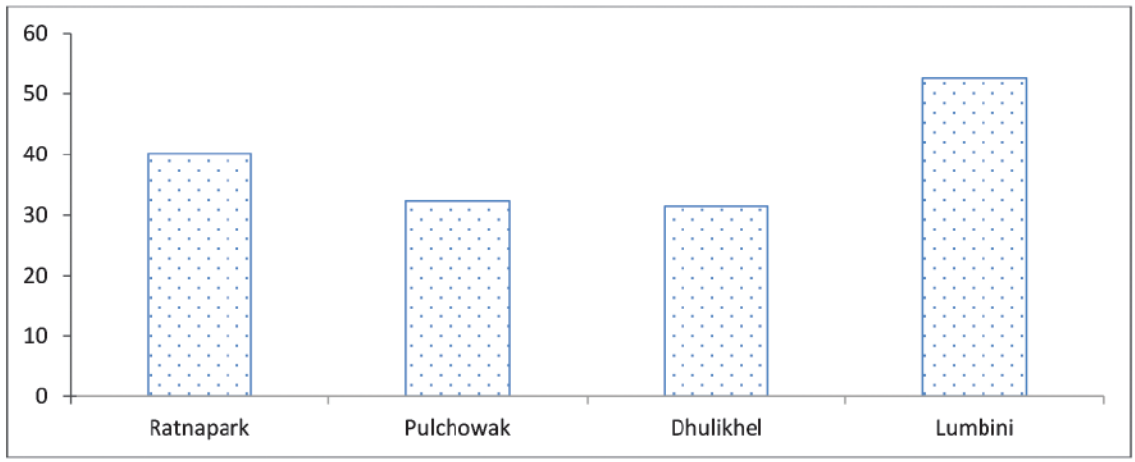

Fig 1:Annual average PM 2.5

The following diagram presents the no of days with full PM2.5 data and the no of days that exceed the national standard for the PM2.5 for four stations that have whole year data.

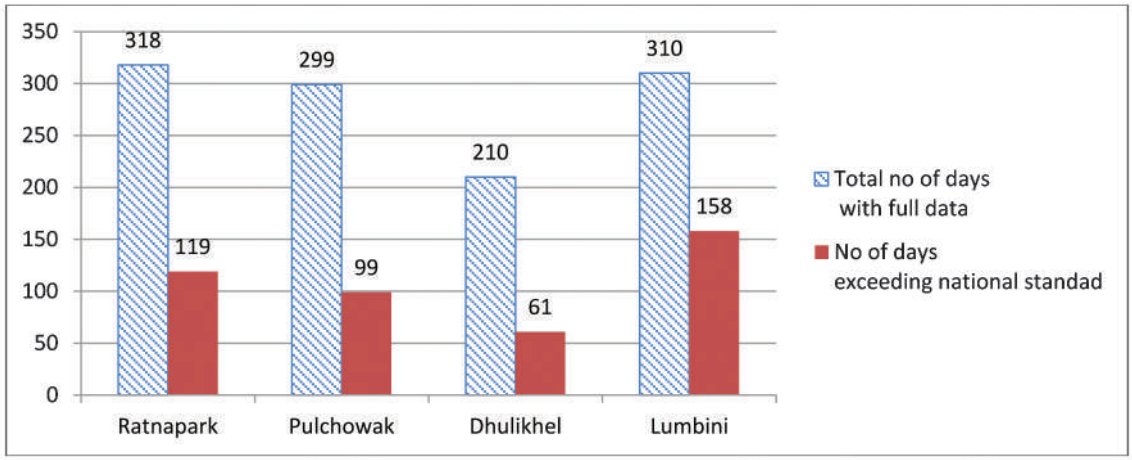

Fig2 NAAQS compliance status of PM 2.5 at different stations

In Lumbini 50.96 % of days do not comply with National ambient air quality standard for PM 2.5. Similarly in Ratnapark, Pulchowk and Dhulikhel the percentage of days not complying with standard is 37.42% , 33.11% and 29.04% respectively.

3.2.PM 10

The annual average PM 10 for the four stations was calculated. Ratnapark has the highest PM 10 value of 91.49 µg/m3 with standard deviation of 77.88 and Pulchok has the lowest value of 38.73 µg/m3 wit standard deviation of 30.17. Similarly annual average PM 10 value for Lumbini is 71.59 µg/m3 with standard deviation of 48.11 and that of Dhulikhel is 56.34 µg/m3 with standard deviation of 30.46.

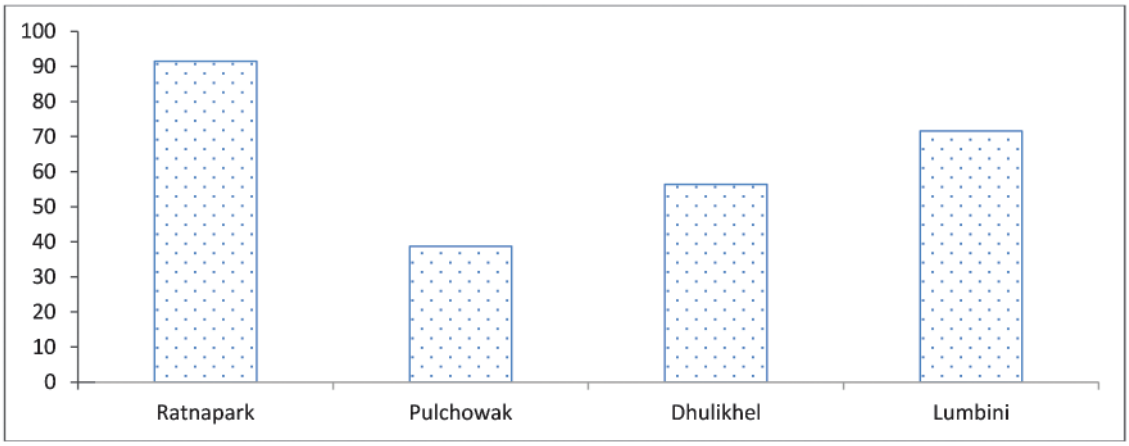

Fig 3: Annual average PM 10 .

The following diagram presents number of days with full PM 10 data and the number of days that exceed the national standard.

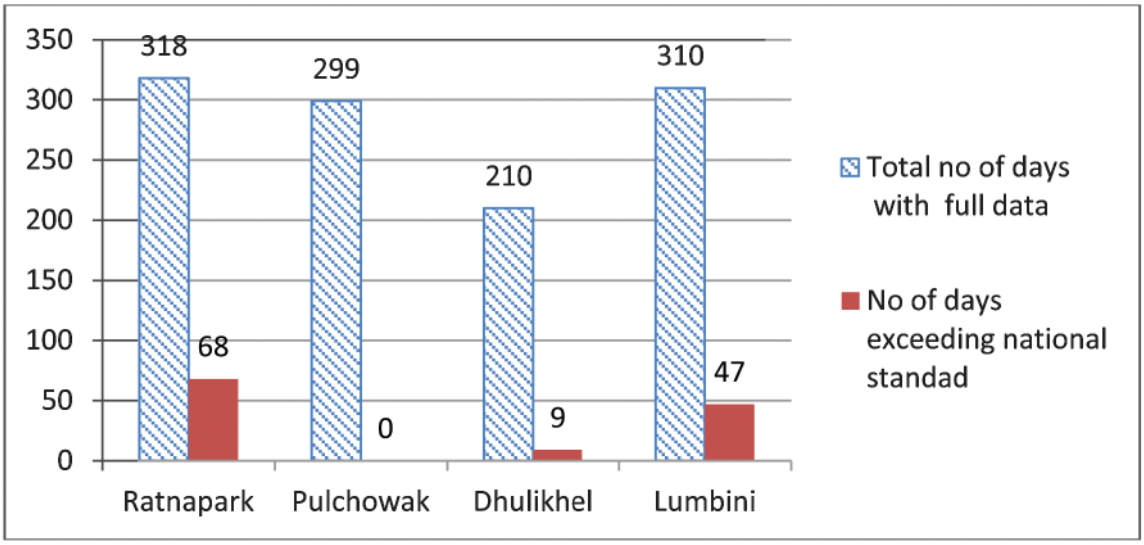

Fig 4:NAAQS compliance status for PM10

In Ratnapark 21.38 % of days do not comply with National ambient air quality standard for PM 10. Similarly in lumbini and Dhulikhel it is 15.16% and 4.28% respectively where as all days comply with standard in Pulchowk

3.3.Total suspended particulate (TSP)

The annual average TSP for the three stations was calculated. TSP for Lumbini is not available. Ratnapark has the highest TSP level of 227.98 µg/m3 with standard deviation of 207.36 and

Pulchowak has the lowest value of 44.74 µg/m3 with standard deviation of 37.08. Similarly annual average PM 10 value for Dhulikhel is 131.90 µg/m3 with standard deviation of 106.61.

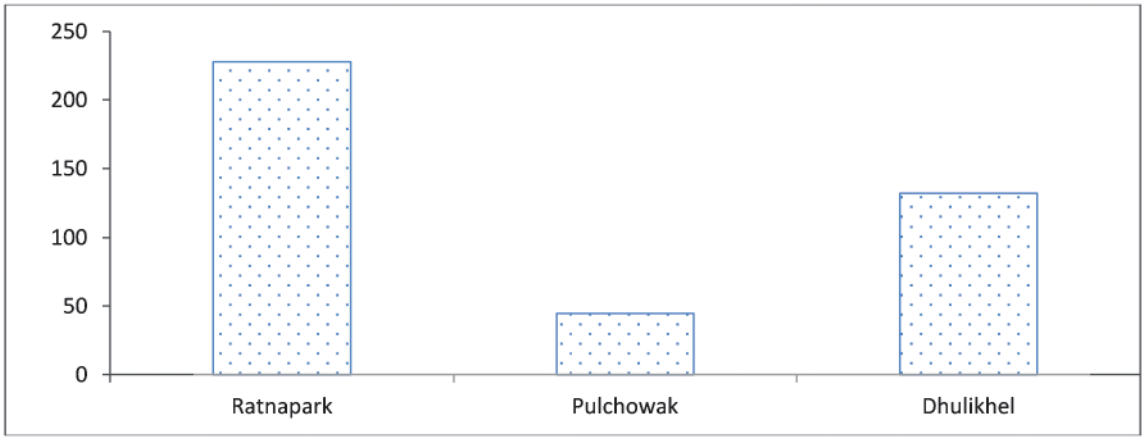

Fig 5 :Annual average of TSP

The following diagram presents no of days with full TSP data and the no of days that exceed the national standard for the TSPM for three stations.

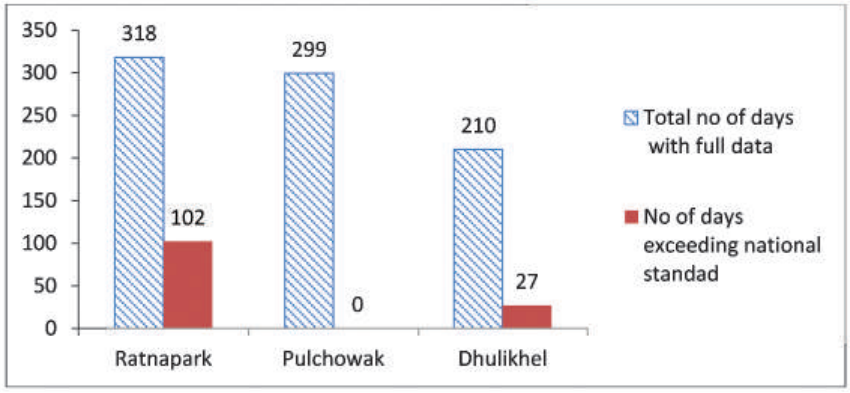

Fig 6 :NAAQS compliance status for TSP

32 % of days in Ratnapark and12.85% of days in Dhulikhel do not comply with National ambient air quality standard for TSP where as all days comply with standard in pulchowk.

3.4. Seasonal variation of Particulate pollution

Graph below shows the daily average PM 2.5 of four stations in 2017. This shows clear seasonal variation of PM 2.5 in all stations. From June to October daily average PM 2.5 is well below national standard in all stations.

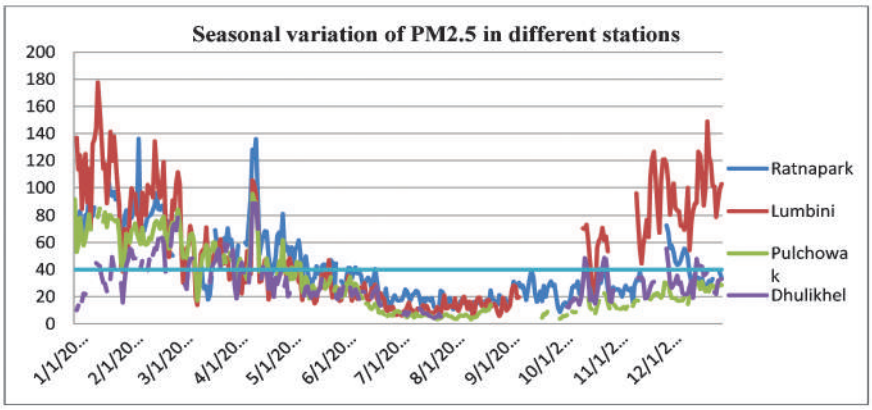

Fig 7: Variation of daily average PM 2.5 for 2017.

During winter PM pollution very high compared to monsoon season. In Lumbini which has highest annual PM 2.5 level has very high daily average of PM 2.5 in the month of January February and November and December.

The following Table shows the percentage of no of days that exceeds the national standards for PM 2.5 in different months.

Stations	Ratnapark	Lumbini	Pulchowk	Dhulikhel
January	100	96.66	100	36.36
February	100	100	100	90
March	58	74.19	89.65	70
April	92.32	40.74	46.66	30.76
May	60.71	20.68	13.33	5.26
June	30	0	0	0
July	13.33	0	0	0
August	0	0	0	-
September	0	0	0	-
October	3.22	80	0	22.22
November	6.25	94.73	0	9
December	44.44	100	0	17.85

Table 1. Percentage of no of days that exceeds the national standards for PM 2.5 in different months.

This table shows during June, July, August and September most of the days meet national standard in all stations for PM 2.5. While during January and February most of the days do not meet national standard for PM 2.5.

Different particle shows different patterns of pollution. Annual average PM 2.5 is highest in Lumbini while annual average PM 10 level is highest in Ratnapark. This shows pollution from fine particle is higher in Lumbini area whereas pollution from relatively coarse particle is high in Kathmandu valley. This indicates different source of particulate pollution dominates in Kathmandu

and Lumbini. The higher pollution of finer particles in Lumbini indicates the main source of particle pollution may be industries, vehicles or transboundary pollution. While in Kathmandu valley the contribution of construction activities and re-suspended dust may be higher. More than 50 percentages of days in Lumbini and more than 37 percentages of days in Ratnapark area do not comply the national standard for PM 2.5. Though pulchowak is near to Ratnapark and has similar condition to Ratnapark it has very low level of PM2.5, PM10 and Tsp. This may be due to the location of the station. The station is at the top of 5 storey building. The particle pollution shows clear seasonality having pollution in winter season.

4 Conclusions

Air quality status of Ratnapark and Lumbini is matter of serious concern. Out of four stations Lumbini has the highest annual average PM 2.5 level while Ratnapark has highest annual average PM 10 level. More than 50 percentages of days in Lumbini and more than 37 percentages of days in Ratnapark area do not comply the national standard for PM 2.5. June, July, August and September have low level of particle pollution while winter season has very high article pollution.

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Vegetation dynamics from edge to interior gradient in Old Padampur area of Chitwan National Park, Nepal

Chandramani Aryal[1], [2] Saroj Pokhrel, RashilaDeshar[1]
*Corresponding author: saroj1pokhrel@gmail.com
[1]Central Department of Environmental Science, Tribhuvan University
[2]Department of Environmental Science, Tri-Chandra Multiple Campus

Abstract

*Understanding the relationship of diversity dynamics and micro-environmental variables are crucial for decision making in Biodiversity conservation. But, the study on the vegetation dynamics and their predictors are limited in case of Nepal. Thus, this study was carried out in Old Padampur area within Chitwan National Park to understand the response of vegetation to micro-environmental variables by using systematic sampling design. In field, first transect location was selected randomly and rest of them were placed at the interval of 50 m. In each transect, five square plots of 10*10 square meter parallel to the forest edge were used to collect data. Species present in each plot and micro-environmental variables were noted down from each plot. The relation of species distribution and micro-environmental variables were explored by using Canonical Correspondence Analysis (CCA). In CCA, constrained ordination explained 26.31% of the variance while unconstrained ordination explains rest 73.69% variance.*

Keywords: *Canonical Correspondence Analysis, ecotone, species richness, Relative Radiation Index, disturbance*

Abbreviations

CCA	Canonical Correspondence Analysis
CNP	Chitwan National Park
RRI	Relative Radiation Index
VDC	Village Development Committee

Introduction

Pattern and process of spatial distribution of species is priority research field in conservation biology (Rosenzweig, 2013). In particular, distinct ecosystem or community types such as forest, wetlands, grasslands were primarily explored in the past but the focus are being shifted towards ecotone where, species composition varies greatly in response to stochastic change in environmental features (Koen Hufkens et al. 2009; Livingston 1903; Risser 1995). Beside, ecotones have a profound influence on adjacent ecosystems as they regulate energy, nutrient, and organisms across landscapes. They are vital to regulate disease transmission, gene flow and community composition and serve as an important indicator of local and global change (Cadenasso and Pickett 2000; Fagan et al. 2003; Hufkens et al. 2009; Strayer et al. 2003; Wiens 1992). Understanding characteristics of ecotone and factors influencing them are vital for conservation of these important ecosystems. Thus, study was carried out to understand the impact of micro-environmental variables (Canopy cover percentage, humidity percentage, nitrogen, phosphorous, potassium, relative radiance index

and organic carbon percentage) on vegetation species distribution at Old Padampur region within Chitwan National Park.

Materials and Methods

Study Area

The research work was conducted at Old Padampur VDC within Chitwan National Park (CNP). This was the only remaining enclave of CNP. Chitwan District lies between 27 0 21' 45" to 27 0 52' 30" N to 83 0 54' 45" to 84 0 48' 15" E. The area extends from the low land Bhabar area to Mahabharata Mountain range, a change in elevation from 141 to 1945 meter. The CNP is one of oldest protected areas in the highly productive Duar grassland ecosystem on the Indo-Gangetic Plain. It is renowned worldwide for its variety and abundance of precious and rare fauna and flora. The climate is subtropical with high humidity throughout the year. CNP is characterized by two major forest types: climax sal forest on well-drained soils and riverine forest on the moremoist areas, dominated by species such as Dalbergia sissoo, Accia catechu, and Bombax ceiba. Furthermore, grasslands cover large areas (Dhakal et al., 2011). It supports the highest density of tigers in Asia, features a high ungulate and carnivore diversity, and provides a habitat for several endangered species. The map of the study area is shown in figure 1.

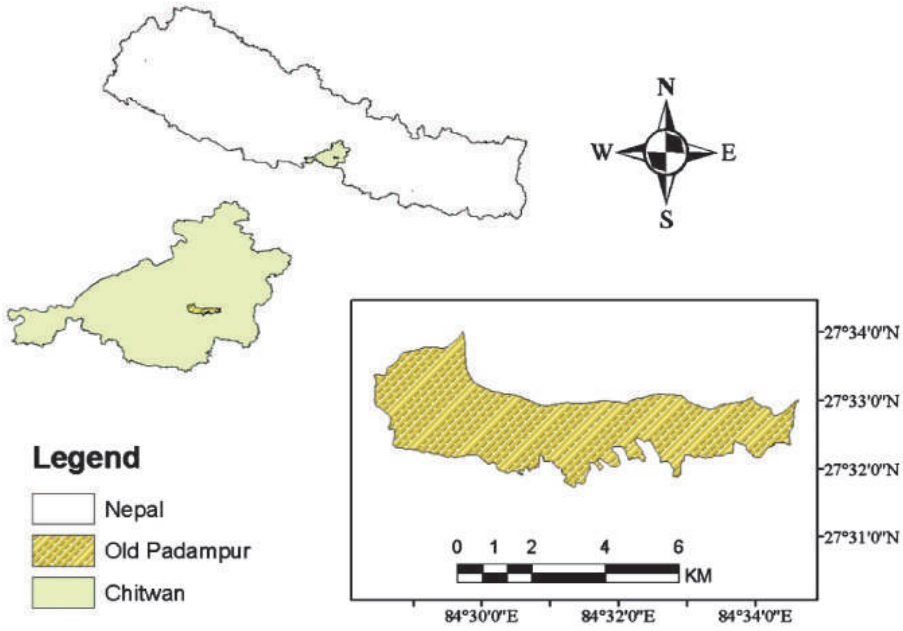

Figure 1: Study Area Map

Research design

Biological diversity is a function of abiotic factors such as climate, nutrient availability and anthropogenic disturbance and interaction with other species (Odum, 1996). Ecotones, zone of interaction between two or more ecosystem, play an important role in materials flow between those ecosystems, speciation, and harbor more species than core areas of adjoining ecosystems

thus hold high conservation value (Kark, 2013). In the study, interaction zone between forest and grassland were considered as ecotone. The vegetation dynamics was calculated as a function of species richness (Fraver, 1994). The soil quality and nutrient availability was determined by the status of soil organic matter, nitrogen, phosphorus and potassium present in the soil. The ecotone properties were determined as a function of vegetation dynamics and soil nutrient availability with comparisons with the forest interior and the edge.

Sampling design

The data was collected in the month of April and May, 2016. Purposive sampling with systemization was employed where data of vegetation, environmental and soil parameter were collected in 50 plots (quadrats of 10m*10m). A total of 10 sampling transects, 80 meter in length was established along the forest edge to interior gradient. For consistency, transects were originated at the base of trees that formed the edges and extended perpendicularly into the forest (Fraver, 1994). Further, care was taken in placing transects, so that adjacent transects were at least 100 m apart. Each transect consisted of five 10x10 m2 plots separated by a distance of 20 m. Plots were excluded, if steeper than 45° slope, with more than 50% rock or exposed soil, having a water stream flowing or well-established trail passing through it, or without a single tree (Paudel & Vetaas, 2014). In each square quadrat (10*10 m2), number of individuals of each species in tree stage were counted. Park authorities have carried out controlled burning in the first week of April, 2016 which hindered our ability to take data on the distribution of herbaceous vegetation.

Soil sampling and analyses

Along the transects, a composite soil sample (of five samples, out of which four taken from each corner of the plot, and one from the center of the plot) was collected in each plot at a depth of 15 cm after removing the surface litter layer. A subsample of the composite sample was immediately transferred to polythene bags and double-sealed. Soil samples taken to the laboratory were air dried, ground to pass a 2 mm sieve, and used for chemical analyses. Samples were analyzed at accredited lab (Agriculture Technology Centre, Jawalakhel). Samples from each plot were analyzed: soil pH in a 1:2.5 mixture of soil and distilled water, organic carbon by Modified Walkley and Black Titration Method (Walkley & Black, 1934), total nitrogen by Kjeldhal Distillation Method (Sarah et al., 2010), potassium by Ammonium Acetate Extraction Method (Normadin et al., 1998) and phosphorus by Modified Olsen method (Olsen & Sommers, 1982).

Micro environmental variables

Micro environmental variables were measured in each plot of all 10 transects. Canopy cover; the proportion of the sky hemisphere obscured by vegetation when viewed from a single point was estimated visually by sitting in the middle of the plot. Relative humidity and air temperature were measured using a portable thermo-hygrometer. The Relative Radiation Index (RRI), which is the relative measure of the substrate's annual exposure to radiation, was estimated as a function of latitude, aspect, and slope (Oke, 1987)

$RRI=Cos\ (180-\Omega)\ Sin(\beta)Sin` +Cos(\beta)Cos`$

Where, RRI is a function of latitude (`), slope (β), aspect (Ω)

Numeric analysis

Species richness was determined as the total number of species per 100m2. Ordination (Canonical Correspondence analysis- CCA) was used to explore the relationship of vegetation and measured environmental and edaphic variables and to examine the relative importance of environmental variables for species composition. From CCA inference on relationship between species composition and micro-environmental variables was explored. Ordination analysis was performed between the species data of all 50 plots and 9 environmental and edaphic variables which includes: air temperature (AT), humidity percentage(HP), canopy cover percentage (CCP), soil pH, total nitrogen percentage (TNP), phosphorus in kg/ha (POKPH), potassium in kg/ha (PKPH), Organic Carbon (OCP) and relative radiation index (RRI). The significance of the analysis was tested using permutation test with 999 permutations using Vegan package (Oksanen et al., 2016) in R Software environment (R Core Team, 2016).

Results

The summary statistics of micro-environmental variables were used for as the predictable variables is shown in table 1.

Table 1: Summary of Descriptive Variables

Parameters	Code	Mean	Standard deviation
Air Temperature (ºC)	AT	37.322	4.429
Humidity (%)	HP	26.38	10.158
Canopy Coverage (%)	CCP	51.920	17.407
pH	PH	6.608	1.162
Total Nitrogen (%)	TNP	0.081	0.0436
Potassium(Kg/ha)	PoKH	252.232	128.470
Organic Carbon (%)	OCP	0.927	0.519
Relative Radiation Index	RRI	-0.577	0.416

Relation of species richness with edaphic and micro-environmental variables

From the CCA result, out of the total variation, 26.31% of the variation is explained by the constrained ordination i.e. by the data of the environmental covariates collected and analyzed and remaining 73.69% of the variation is explained by the unconstrained ordination (Table 2).

Table 2: Proportion of inertia explained by constrained and unconstrained ordination

	Inertia	Proportion	Rank
Total	6.0255	1	
Constrained	1.5852	0.2631	9
Unconstrained	4.4403	0.7369	24

From the eigenvalues of the constrained axes, it was observed that the 46.93% of the variation is explained by CCA1, 19.47% by CCA2 and so on (Table 2).

Table 3: Amount of variation explained by different CCA
Table 3: Amount of variation explained by different CCA

CCA	Proportion of variation explained by CCA	Variation explained by CCA (in percentage)	Cumulative Variation explained
CCA1	0.7441	46.937	46.937
CCA2	0.3086	19.466	66.403
CCA3	0.1532	9.6638	76.0668
CCA4	0.1393	8.787	84.8538
CCA5	0.1027	6.4783	91.3321
CCA6	0.0688	4.3399	95.672
CCA7	0.0373	2.3529	98.0249
CCA8	0.0202	1.2742	99.2991
CCA9	0.0111	0.7002	99.9993

The tri-plot of the result of Canonical Correspondence Analysis is shown in the figure 2 where the influence of the environmental variables and spatial variables is determined.

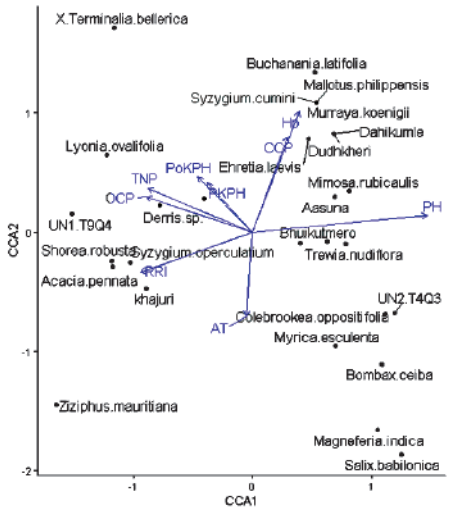

Figure 2: Triplot showing the effect of different micro environmental variables in species composition

It is observed that the distribution of Salix babylonica, Magnifera indica, Bombax ceiba, Myrica esculenta, Colebrokea oppositfolia, Myrsine sp., Symplocos racemosa and Trewia nudifloraare governed by Air temperature (AT) and pH. Organic carbon percentage (OCP), total nitrogen percentage (TNP), potassium in kg/ha (PoKPH) and phosphorous in kg/ha (PKPH) are responsible for the distribution of Terminalia bellerica, Lyonia ovalifolia, Litsea monopetala and Derris sps. Relative Radiance Index (RRI) and air temperature combine to contribute to the distribution of Zizyphus mauritiana, Solanum aculeatissimum, Osyris wightiana and Cleistocalyx operculatus.

While,the distribution of Acacia pennata, Buchanania latifolia, Terminoliaaa lata, Ehretialaevis, Shorea robusta and "Bhuikutmiro" distribution are governed by the Humidity percentage (Hp), pH and canopy cover percentage (CCP). The obtained result differs slightly when the site is not considered (figure 3) below:

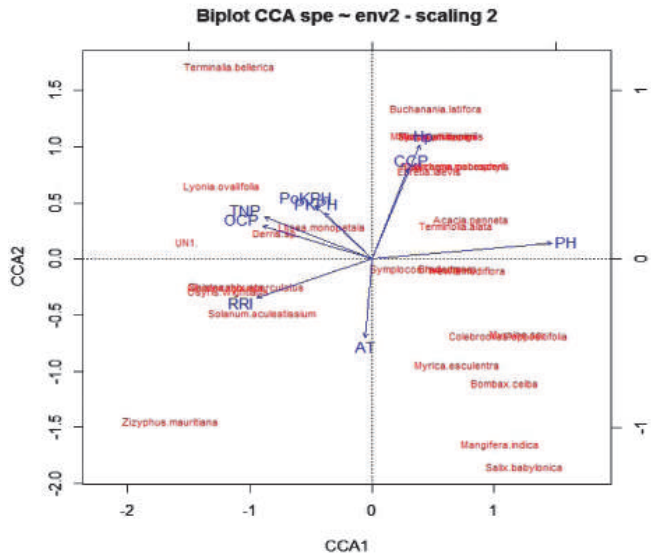

Figure 3: Biplot CCA showing the impact of environmental variables without site

The model developed is significant at 95% level of confidence as obtained from permutation test after 999 iteration.

Discussion

Species composition was found to vary with reference to micro-environmental variables as shown by CCA triplot. This is similar to other studies that the species composition changes with the slight change in the environmental conditions (Chaturvedi et al., 2011). The variation in species composition is observed in other area while moving from edge to interior but in case of this study no significant change was observed. This might be because the edge of the forest lies in the core area as a result of which there is no other external disturbance factor from other anthropogenic source except from the park staff. No gradient of disturbance due to controlled burning was observed on moving from edge to interior of the forest.

Twenty-two species of tree were reported from the area. But even a single species was not found which loves edge. This might be the result of controlled burning and other management practices. This is similar to the study done by Timilsina et al. (2007) which concluded that past disturbances (fire and human settlement in the past) are mainly responsible for species richness and diversity in Sal Forest in Terai region of Nepal. Low species richness per quadrat might be the effect of disturbance especially controlled burning which was observed during the field visit.

The spatial and temporal distribution of species assemblages is primarily by fire, cutting and grazing in Chitwan National Park as described by Peet et al., (1999). The change in the impact of these disturbances, for example a change in the fire regime, will alter the diversity and distribution of

the plant assemblages together with their associated fauna. During the study period, the controlled burning was observed majorly in edge of forest and grassland and the floor of interior forest which might be the cause for low species richness. The species diversity is sustained by dynamic attributes of the patches which can be generated and modified by disturbances originating from human activities and natural processes. Management practices contributed largely to the variation of canopy openings, trampling by the trekkers added heterogeneity by soil compaction. These anthropogenic and natural disturbances interacted to effect the pattern of plant species diversity and composition (Bhuju & Ohsawa, 2001). Since the study area is in small spatial scale there is less variation in site-specific microclimate (Murcia, 1995). So, it may be unrealistic to expect all edge effects to vary monotonically with distance from the edge.

Conclusions

The expected pattern of change in species composition was not observed along the edge to interior gradient. The response of different species to the micro environmental variables differed considerably by species. But, as only 26.31% of the response was explained by constrained ordination further studies incorporating the disturbance dynamics and larger spatial scale are necessary to understand the species richness dynamics and their relationship with micro-environmental variables.

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Environmental Compliance status of Cement Industries of Dang, Nawalparasi and Dhading districts of Nepal.

Rajeshor Paudel, Govinda Prasad lamichhane
*Department of Environment, Babarmahal, Nepal.
Corresponding email:-rajeshor_paudel@yahoo.com

Abstract

Many environmental effects are linked to cement industries. Dust pollution and noise pollution are major environmental effects of cement industries of Nepal. Government of Nepal has enacted Environmental Protection Act- 1997, Environmental Protection Regulation-1997 and various environmental standards for the control of pollution. Standard for dust emitted from cement and crusher industries is one of such standard. Four cement industries from Dang, Nawalparasi and Dhading were selected for compliance monitoring by Department of Environment. Compliance monitoring was done in between January 2018 to January 2019. Checklist developed by Department of Environment was used for the collection of information. Most of the industries studied are near to major highways of Nepal. All of the industries were limestone based industries having their own quarry sites. None of the industries fully comply all the provisions of the standard. All the industries studied have installed pollution control devices like Bag filter to control the dust from Mills and Kilns. Some industries are also found using Electrostatic Precipitator to control dust and such industries are found more effective in dust control. None of the industries were found having wind breaking walls, metallic road within industries premises, cleaning and washing practices of industry floor area and green belt around the industries.

Key words: *Dust pollution, Noise pollution, Pollution control devices, Green Belt, Wind breaking Walls.*

1. Introduction

Cement industries is one of important industrial sector in Nepal which supplies construction material like cement and clinker. It is a very important construction material for many sectors like road, hydropower, buildings and many others. Many environmental effects are linked to these industries. The cement industry is an energy intensive and significant contributor to climate change.

The major environment health and safety issues associated with cement production are emissions to air and energy use. Cement manufacturing requires huge amount of non renewable resources like raw material and fossil fuels. It is estimated that 5- 6% of all carbon dioxide greenhouse gases generated by human activities originates from cement production (Potgieter Johannes H., 2012). These emissions are not only deteriorating air quality but also degrading human health. Emissions have local and global environment impact resulting in global warming, ozone depletion, acid rain, biodiversity loss, reduced crop productivity etc (Pariyar Suman K, Das Tapash, Ferdous Tanima, 2013). Scientific evidence indicates that air pollution from the combustion of fossil fuels causes a spectrum of health effects from allergy to death (Marchwinska-Wyrwal E., Dziubanek G., Hajo I., Rusin M., Oleksiuk K. and Kubasiak M., 2011). The results of several studies showed that these

emissions are adversely affecting human health in a variety of ways, like itchy eyes, respiratory diseases like tuberculosis, chest discomfort, chronic bronchitis, asthma attacks, cardio-vascular diseases and even premature death (Mehraj.S, Bhat G.A., Balkhi. H.M, 2013).

Government of Nepal has enacted Environmental Protection Act- 1997, Environmental Protection Regulation-1997 and various environmental standards for the control of pollution. Nepal government has formulated environmental standards for cement industries. In this study the compliance status of some cement industries of Nepal has been assessed. The actual environmental impact of cement industries is not the scope of this study.Monitoring of limestone based industry which undergo crushing operation has been selected for the purpose of study. This is based on the assumption that Limestone crushing based industries has more detrimental environmental impacts than Clinker based industries.

Legal provision

Section 7 and sub-section 1 of Environment Protection act, 1997(EPA, 1997) states that "Nobody shall create pollution in such a manner as to cause significant adverse impacts on the environment or likely to be hazardous to public life and people's health, or dispose or cause to be disposed sound, heat radioactive rays and wastes from any mechanical devices, industrial enterprises, or other places contrary to the prescribed standards."

Crusher industries should conduct environmental study called Initial Environmental Examination (IEE) (below 3000TPD capacity) and Environmental Impact Assessment (EIA) (above 3000TPD capacity)and these reports should be approved before the establishment of industry. Annex 1 and Annex 2 of Environmental Protection Regulation, 1997 provides the threshold for choosing IEE or EIA.

The emission limit of Total Suspended Particulate has been set 500µg/Nm3by Nepal government. Besides crusher industries has to maintain following conditions within industries premises.

A. Should have Dust Containment and Dust Suppression system in the machines.
B. Should construct wind breaking wall
C. Should construct Metallic roads within industry premises.
D. Should clean and wash industries premises surface regularly.
E. Should construct Green Belt around the industries.(Nepal Gazette, 2012)

2. Methodology

Environmental Compliance Monitoring was conducted in Dang, Nawalparasi and Dhading districts in between January 2018 to January 2019 as a part of regular compliance monitoring program of Department of Environment. Dhading district lies in Province three adjoining to Kathmandu Valley in the middle part of the country and Nawalparasi and Dang district lies in the Province five and western part of Nepal. Many cement industries are operated in these districts. Four cement industries monitored during these periods were assessed for this study. Out of four industries one industry is from Dang districts, one from Nawalparasi and two from Dhading district.

Information collected during compliance monitoring is analyzed in this study. Checklist developed by Department of Environment was used for collecting information. During compliance monitoring information was collected by direct observation and interviewing owner or representative of the industries. General Information of the industries and information needed for evaluating the compliance to the environmental standard was collected.

Location of industries

All the cement industries selected for the study lies along the highways. Out of four industries one industries lies near by east west Mahendra highway, one nearby Tribhuvan Rajpath, one nearby Prithvi highway and one nearby major road accessing to Dang. Except one industry all other industries have residential and agricultural area in their vicinities.

Sources of Raw materials

These industries collect raw materials from the quarry sites of limestone in the hilly areas. All the industries monitored have their own quarry site. The hauling distance for the collection of raw materials ranges from 20 to 35 km. Most of the industries collects uncrushed limestone from the quarry site. One industry has initiated to collect the crushed limestone from the quarry site. Huge numbers of trippers were found used in transporting limestone from the quarry site.

3. Results and Discussion

3.1 Initial Environmental Examination (IEE) Report

IEE report includes environmental mitigation plan made by the industries. All the industries monitored are found below the capacity of 3000 TPD and are found carrying out IEE. All of the industries were found unaware of the importance of the IEE report. Of the four industries two industries were found having IEE report in the field office and two were found not having IEE report in the field office. None of the representative of the industries exactly knows what IEE report is and what is written in the environmental management plan. The representative of the industries said the report may be in the head office.

3.2 Air pollution

It was observed that dust was produced during the cement production process. Crushing of limestone was found to be the major source of dust. The other major sources found are kiln, cement packing operation and raw mill. The other significant source of dust found in all the industries was movement of large number of vehicles within the industry premises. The thick dust accumulated in the industry premises was found blown into the air during vehicles movement. Windblown dust from piles of raw materials and dust deposited on the floors was another source of dust pollution. All the industries were found having installed bag filter for the control of dusts from kiln and mills. Three out of four were found using Electrostatic Precipitator which is quite significant pollution control device.All the monitored industries were found having very insignificant water spray system especially spraying water around the major entry point (gate) only. None of the industries were found spraying water in the inner side of the industries. Two out of four industries have access road in semi paved condition. Vehicular movement on the access road is another source of dust pollution.

3.3 Water pollution

Cement production is mostly dry production process. None of the industries were found discharging waste water from the production process. The major portion of waste water was found discharged from the residential area within the premises of all the monitored industries. Besides there was possibility of sweeping the dust accumulated in the ground floor during the rain in all the industries discharging waste water. None of the industries were found having proper drainage system and any kind of treatment system for the waste water. All the industries were found discharging waste water into nearby streams and rivulets.

3.4 Noise pollution

The major sources of noise found in all the industries were crushing of limestone, raw mill, raw material conveyor belt, movement of heavy vehicles and diesel generator. Significant noise level was found inside the industry area. None of the industries were found having acoustics system to control the noise from the above sources. None of the industries were found having green belts and walls to minimize the noise around the industry. None of the industry are found providing ear muffs to their workers as a safety precaution.

3.5 Compliance status of industries with respect to environmental standard for dust emitted from cement industries.

A. Emission standard of Total Suspended Particulate matter

During compliance monitoring suspended particulate matter (SPM) emitted from the industries was measured for only one industry. The SPM value of the measured industry was found within standard value and very nearby the breaching point of the standard. Two out of four industries were found measuring total suspended particulate matter as a part of self-inspection. The monitoring results carried by the industries have shown their compliance with respect to government standards.

B. Dust Containment and Dust Suppression system in the machines

All the monitored industries were found installing bag filter and three out of four have installed electrostatic precipitator as a dust control system. These systems were found in operation during the monitoring work. One industry that did not have electrostatic precipitator as a pollution control device was found emitting more dust in comparison to others.

C. Wind breaking wall

In the standard the wind breaking walls are not defined clearly. Type of wall and their dimensions is not mentioned. However a simple type wall around the industries may be effective for windblown dust. None of the industries have fully developed wind breaking walls in all sides of the industry. All the industry were found having wall at the main gate side and rest of the sides were fenced with metallic pointed ropes.

D. Metallic roads within industry premises.

None of the industries were found having metallic road within industries premises. One industry out of four was found having started for making metallic road nearby the main gate entrance area.

E. Cleaning and washing industries premises floor surface regularly.

All of the industries monitored were found spraying water inside the industry around the main gate side but none of the industries were found spraying water in the inner side. None of the industries were found washing industries floor surface. Since the floor area of industries is not of concreted and road within the industry premises is not metallic it did not seem possible to wash and clean industries premise floor surface. Thick accumulation of dust was found in all the industries premises during the monitoring.

F. Green Belt around the Industry

Although all of the monitored industries have planted some trees in some sides of the industries none of the industries has good greenbelt around the industry. While asking about green belt around the industries they showed us the trees in the industry premises. Hence industry authorities don't have proper understanding of greenbelt and its importance.

4. Conclusion

Air pollution and Noise pollution are major issues on all of the industries. The criterion of wind breaking wall, green belt, metallic road and regular washing of floor surface inside the industry premise are found noncompliance with respect to the government standard. None of the industries were found aware of implementing the mitigation measures written in Initial Environment Examination (IEE) report.

Environmental performance of the cement industry was found unsatisfactory. Of the five provisions of the standards all industries comply with first provision of the standard, dust containment and dust suppression system in the machine partially. Rest of the provisions is not complied by any of the studied industries.

Formulation of Environmental Management Plan and establishment of Environmental Management Unit in the industry will be helpful to achieve the government requirements and environment goals.

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Environmental Compliance Monitoring Of Environmental Assessment (Ea) Implementation Of Different Projects With Special Emphasis On Muck Management

P. Neupane[1] Department of Environmental Science, Tri Chandra Multiple Campus, Tribhuvan University, KathmanduCorresponding E-mail: neupanep73@gmail.com
P. Basnet[2] Department of Environmental Science, Tri Chandra Multiple Campus, Tribhuvan University, KathmanduCorresponding E-mail: prakashbasnet@gmail.com
Mamata Aryal[3] Department of Environmental Science, Tri Chandra Multiple Campus, T.U.
Corresponding E-mail: mamta.aryal054@gmail.com

Abstract

Environmental Assessment (EA) in Nepal is made mandatory by EPA 1997. EPR 1997 states regular monitoring as mandatory. Despite decade's long practice, only a handful of studies are made on the compliance monitoring of EA implementations in Nepal. This study intends to carry out environmental compliance monitoring of the implementation of EMPs prescribed by EA of selected projects with special emphasis on muck management. The report is a comparison of EMP prescriptions versus field status, based on visual observations and key informant interviews. The study indicates that the projects have maintained compliance in use of disposal sites, however, failed in terms of maintenance of drainage, slope protection and siltation control facilities. On-compliances in re-plantation and topsoil excavation from the disposal area were observed. Also, the mucks were disposed over flood plains, which are prohibited by the EA indicating lack of internalization of EA practices and efforts in muck management.

Keywords: *Siltation, EMP, Slope*

Introduction

Environmental Assessment is a structured approach for obtaining and evaluating environmental information prior to its use in decision-making in the development process (Bisset, 1996). Compliance monitoring is a continuous measurement of environmental parameters to ensure that regulatory requirements and standards are met (Puja, 2006).As a subset of environmental monitoring, muck management issues are an important part of assessing the potential impacts of construction projects. Poorly managed soils can cause depletion in the aquatic environments (Newcombe, 2011)and siltation problems in agriculture. Hence, monitoring plays a significant role in the post-decision stage of the processes system for developmental projects in Nepal was established by the formulation of EPA 1996 and EPR 1997. Yet, this process is completed only for approval from concerned ministry and governmental agencies (Roy, 2002).Thus, this study is important to evaluate EMP provision, field status and assess their compliance in terms of muck management.

Materials and Methods

Study area:

The study was carried out in three selected development project sites i.e. Kulekhani III Hydroelectric Project (14 MW) developed byNepal Electricity Authorityin Makwanpur district,

Dordi Khola Hydropower Project (27 MW) developed by Himalayan Power Partners in Lamjung district and Madhya Bhotekoshi Hydroelectric Project (102 MW) developed by Chilime Group of Companies in Sindhupalchok district. All of them lie in the hilly region of Nepal. The study areas and their location on the map of Nepal are shown in figure 1

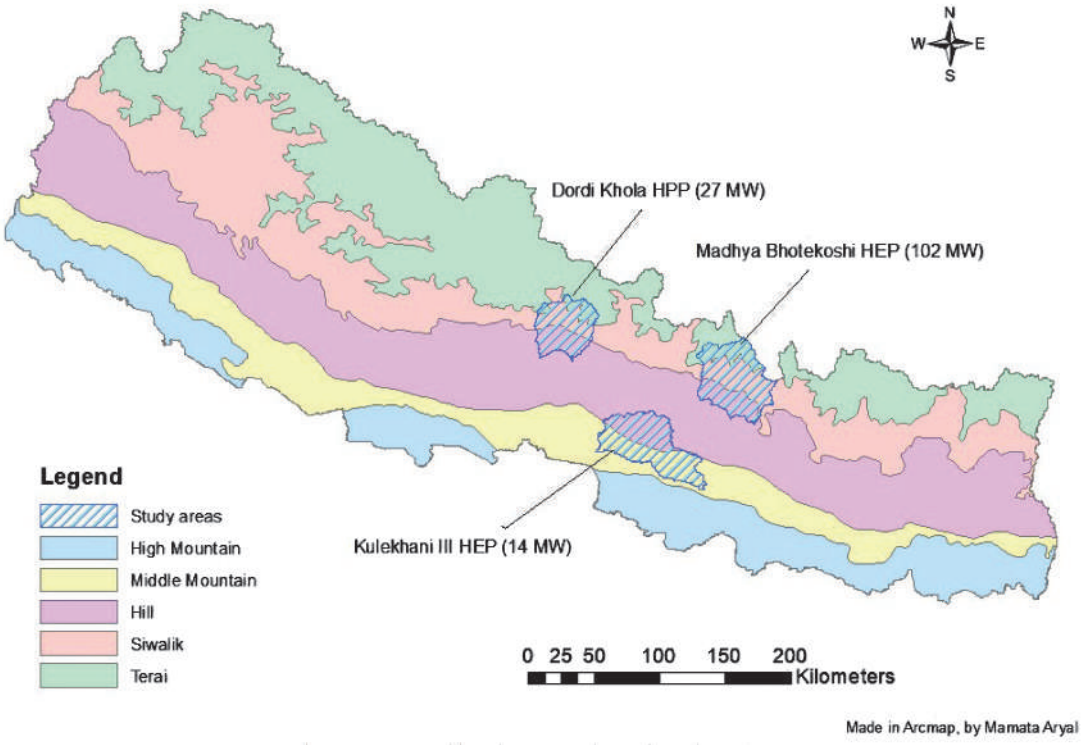

Figure 7: Map Showing Location of Project Areas

Data Collection:

Data were generated using field observation, review of project reports and inspection guidelines and a key informant interview. The project reports were reviewed to prepare the checklists of the observation. The reports reviewed included EIA of Madhya Bhotekoshi Hydroelectric Project, IEE of Dordi Khola Hydropower Project, IEE of Kulekhani III Hydropower Project and quarterly monitoring reports of these projects. A walkthrough survey of the projects starting from headworks through the alignment roads to the tailrace was performed and the measures taken for muck management were reviewed. The disposal sites were observed and an investigation on the effectiveness of the management measures and the implementation of the EIA recommendations was duly considered for the study. Likewise, discussion regarding the management of the mucks produced was made with key informants, EMU staffs of the project. Information regarding muck management, especially spoil disposal during the construction phase of the project was considered.

Data Analysis

The data collected were analyzed based on the checklist survey and after the field observation; an expert consultation was carried out. Discussions were held on the results obtained and the compliance level of the EIA recommendations was evaluated. The possible reasons except for those from the field were also analyzed before the compilation of the report.

Results

From table 1, we can observe the parameters, their provision in the EMP and the results as observed in the field. The compliance with the EMP provisions was found in the aspects of the muck management plan, allocation of spoil disposal sites, social issues and vegetation cover.

Table 6 Table contrasting EMP provision and field observation

S. N.	Parameters	Kulekhani III HEP		DordiKhola HPP		Madhya Bhotekoshi HEP	
		Provision in EMP	**Field Observation**	**Provision in EMP**	**Field Observation**	**Provision in EMP**	**Field Observation**
1	Muck Management Plan	Formulation of Muck management plan	Not Available	Formulation of Muck management plan	Not Available	Formulation of Muck management plan	Not Available
2	Siltation Control Measures	Adoption of Siltation control measures	No	Adoption of Siltation control measures	No	Adoption of Siltation control measures	No
3	Slope Protection Measures	Slope maintained below 45°	Yes	Slope maintained below 45°	Yes	Slope maintained below 45°	Yes
		Bioengineered to reduce slope failure	No	Bioengineered to reduce slope failure	No	Bioengineered to reduce slope failure	No
4	Spoil disposed in the water	Disposal will be strictly prohibited	Disposed on the banks	Disposal will be strictly prohibited	Disposed on the banks	Disposal will be strictly prohibited	Disposed on the banks
5	Reuse of muck	Will be reused to the maximum extent	Reused as road covers and backfills	Will be reused to the maximum extent	Reused as road covers and backfills	Will be reused to the maximum extent	Reused as road covers and backfills

S. N.	Parameters	Kulekhani III HEP		DordiKhola HPP		Madhya Bhotekoshi HEP	
		Provision in EMP	Field Observation	Provision in EMP	Field Observation	Provision in EMP	Field Observation
7	SD sites	Muck will be deposited on 3 sites	5 SD sites observed	No no. of SD sites defined	3 SD sites	Muck will be deposited on 5 SD sites	6 SD sites observed
		Disposal site shall be stable	all the SD sites were not stable	Disposal site shall be stable	all the SD sites were stable	Disposal site shall be stable	all the SD sites were not stable
		No disposal on the river banks	SD sites located on the flood plain	No disposal on the river banks	SD sites located far from the flood plain	No disposal on the river banks	SD sites located on the flood plain
		SD sites shall be given gabion protection	Toe gabion in some sites	SD sites shall be given gabion protection	No	SD sites shall be given gabion protection	No
		SD sites shall be covered by vegetation	Yes	SD sites shall be covered by vegetation	No	SD sites shall be covered by vegetation	No
		Spoil deposited shall be levelled	Only in some SD sites	Spoil deposited shall be levelled	Only in some SD sites	Spoil deposited shall be levelled	Only in some SD sites
8	Top Soil Cover	Will be Collected	No	Will be Collected	Yes	Will be Collected	No
		Will be covered	No	Will be covered	No	Will be covered	No
		Will be well drained	No	Will be well drained	No	Will be well drained	No
		Will be reused	Not applicable	Will be reused	Not applicable	Will be reused	Not applicable
9	Air Quality	The timely sprayer of water to reduce dust in the atmosphere	Water sprayed	The timely sprayer of water to reduce dust in the atmosphere	Water sprayed	The timely sprayer of water to reduce dust in the atmosphere	Water sprayed
10	Water Quality	Muck won't be deposited into river and banks	Turbid water due to muck	Muck won't be deposited into river and banks	Yes	Muck won't be deposited into river and banks	Turbid water due to muck

Discussion

All three selected projects lie in the Hilly region and consist of headrace tunnel as a major part of their structure, thus generating a huge amount of muck. Environmental studies have prescribed disposal sites. The sites recommended were under use and compliance in terms of location, protection facilities and muck leveling was observed. But there were sites used for disposal other

than EA prescription which had major noncompliance issues. These sites were located on sloppy areas, on flood plains with no erosion protection, which might lead into the downstream turbidity.

The projects were adaptive enough to cope with the unpredicted usage of the muck. Muck was used as road covers, to backfill the ridges as per the request of the community or need of the project. Yet, the project sites were not clear of trashes of mucks. The mucks excavated were reused as suggested by the environmental studies. Good quality mucks were reused as construction aggregates by both project and local communities.

Negative compliance heavily persisted in the aspects where much planning and efforts were required, for example, siltation control, slope protection measures, drainage facilities were observed though mentioned in the recommendations, in any of the disposal sites. The potential landslide zones, humps of spoils disposed are required to be bioengineered or planted with the local species of vegetation. As per the field visits made to the projects under study, the compensatory tree plantation though looked very effective in other areas, plantation over muck disposal sites were ignored by the projects. The humps of mucks were being succeeded by the lichens. There have been efforts for vegetation cover over the disposed muck, but they do not seem satisfactory. Hence, proper attention in plantation over the muck disposal sites is recommended. Slope protection measures were adopted only in some cases. Protection measures failed to prevent erosion in some disposal sites.

Conclusion

The construction of tunnels, access roads and other structures generates a huge amount of muck in hydropower projects. Thus, a clear muck management plan is necessary for the proper management of muck. Similarly, the type of muck that shall be generated and ways for their optimum reuse should be planned before the construction phase. Type of muck and was well estimated, but the minimum facilities for the disposal area were lacking. For example, no drainage structures were observed in any of the projects studied. Negative compliances were observed in the aspects requiring meticulous planning and efforts. Still, further research on the aspects of environmental compliance monitoring and muck management is required. Proper planning of disposal sites and methods are necessary for better compliance. More efforts on muck management and internalization of EA practices can definitely enhance the compliance of EA implementation. For this, tri-parties viz. Consultant, Client and Contractor should carry out smooth coordination for the effective implementation of the recommendation of environmental assessments for environmental sustainability.

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Rate of carbon sequestration estimation in soils of Bailbandha buffer zone community forest, Far western Nepal.

Laxmi Thagunna
Department of Environment, Ministry of Forest and Environment
Corresponding Author: laxmithagunna@gmail.com

Abstract

*Soil organic carbon sequestration is the process by which carbon is fixed from the atmosphere via plants or organic residues and stored in the soil. This study consists of periodical comparison of soil organic carbon from same site of Bailbandha (BBZCF) of far western Nepal in same season at 2008 and 2017 AD. The main purpose of the study was to estimate the rate of soil organic carbon sequestration in soils of Bailbandha Buffer Zone Community Forest which lies within Suklaphanta National Park. Random sampling using quadrates of 400 * 400 m2 were used to collect the data. Sixty soil samples were collected from thirty different sites within quadrates at two depths of 0-25 cm and 25-50 cm with core sampler. Soil organic carbon was estimated with Walkely Black method. A total of 3724.75±31.3 and 1568.81±9.12 tones soil organic carbon was estimated in 2008 and 2017 AD respectively. Soil organic carbon sequestration rate of the community forest was found at -240 tons per year, i.e., the carbon sequestration rate was found negative which indicates that forest has lost soil organic carbon between two consequent studies in 2008 and 2017 AD in the same season.*

Key Words: *Community forest, organic matter, carbon loss.*

Background

There are major five pools of carbon namely ocean, geologic formation, soil, atmosphere and biotic pool. Soil is the third largest pool of carbon reservoir after ocean and geological formations containing 2500 pg to 1 m depth (Lal, 2011). SOC is dynamic, however, and anthropogenic impacts on soil can turn it into net source or a net source of GHGs (FAO,2017) The Intergovernmental Panel on Climate Change (IPCC) is now 95 percent certain that humans are the main cause of current global warming (IPCC, 2014). In addition , the SYR (Synthesis Report) finds that the more human activities disrupt the climate, the greater the risks of severe, pervasive and irreversible impacts for people and ecosystem, and long lasting changes in all components of the climate system (ibid). Soils are a major carbon reservoir containing more carbon than the atmosphere and terrestrial vegetation combined (FAO, 2017) that's why small changes in SOC stocks can significantly affect atmospheric C concentrations (Singh et. al, 2018). This study was conducted to estimate the soil organic carbon sequestration rate at BBBZCF to know its implication to climate change.

Materials and Methods

i) Study Area

Study area lies Dodhara Chandani municipality of Kanchanpur district, far west Nepal. It is a buffer zone community forest of Suklaphanta National Park. This community forest is situated at

the bank of Mahakali River which acts as the boundary between two countries Nepal and India. Nepal lies in left side of this River while India lies in the right side.Dodhara Chandani municipality lies in the right side of the Mahakali River The BBBZCF makes a part of the Chandani village. This community forest is bordered by Mahakali barrage in the east; Indian border in west and north and by settlement area of ward no. 7 of Dodhara Chandani municipality. It covers 58.77 hectares. The forest type is mainly khair *(Acacia catechu)* and Sisso *(Dalbersia sissoo)* mixed with other species of trees and shrubs.

ii) Periodical Changes on BBZCF in 2008 and 2017 AD

During the first phase, i.e., 2008 AD of this study, there was an office in a small building constructed from earning of community forest resources. They had long and short term management and development plans for the community forests as well as the forest user groups. The community forest area was well bounded with barbed wire. In 2059 BS, plantation was made in 25 hectares by District Forest Office (DFO) Kanchanpur. The planted species were Sishum (Dalbergia sissoo), khair (Acacia catechu) and sagban / Tik (Tectona grandis) .The plantation was successful and was in the regeneration stage, i.e., the diameter at breast height (Dbh) of planted trees was below 10 cm. These plantations were around the few mother trees left in the forest. The condition of forest was at recovering stage as a result of management efforts of the BBBZCF User Groups.

But the scenario was found drastically changed during our second time visit in 2017. The office building was in abandoned form and was not in use. The office building was in abandoned form and not in use for the CFUG meetings and other interactions. After interviewing with the key informant and the people living near the forest, it came to know that the management team of the CFUG had changed many times since then and none of them worked for the development of the CF. They just fulfilled their personal interest by exploiting the forest resources. Now, Forest was in degraded condition due to poor management, illegal felling for timber, fodder, fuel wood, by the Nepalese people as well as the Indian peoples living near the border accompanied by flood during 2014.

Flood from the Mahakali River inundated the community forest and leave it with eroded top soil and deposition of thick layer of sand covering the fertile soil below it.

iii) Soil Sampling, analysis and calculation

a.) Sampling

Quadrates (400* 400m2) method was used with random sampling. Sampling was done at the meeting point of two diagonals of the quadrates for bulk density and soil organic carbon measurement from two layers, 0-25 cm and 25 to 50 cm using core sampler. Tube length of core sampler was 25 centimeter. For bulk density sampling the tube core was inserted into the soil using hammer. Later on, soil around the tube core was removed with shovel and the soil was transferred to the sampling bag in undisturbed form as far as possible. Again the tube core was inserted within the same pit up from 25 cm to 50 cm and the sample was transferred to the sampling bag and tagged with the sample number, number of quadrate and the depth to which it belong and the date of sampling. Sampling of SOC measurement was done following the same

steps at another pit quite near the first one and transferred to the sampling bag with all details written outside the sample bag. All together 120 Soil samples were collected from 30 sites at two depths of 0-25cm and 25-50 cm with core sampler.

b) Bulk Density

The bulk density was determined by 'tube core method' according to Baruah and Barthakur, 1999. Fresh weight of the soil was taken and then kept in oven at a temperature of 105oC for more than 24 hr until constant weight was obtained. The weight of dry soil was taken after cooling it. Bulk density is then calculated from the measurement of bulk volume using the soil auger length and the diameter of the cutting edge of the sampler and calculated as follows:

Bulk density= dry weight of soil sampler (gm)/volume of core sampler (cm3)
Volume of core sampler= πr2h (cm3)
Inner diameter of the core=d cm
Height of core sampler=h cm
ii. Percentage organic carbon:

c) Soil Organic Carbon (SOC)

Percentage organic carbon was determined by titrimetric determination (Walkley and Black, 1934).The collected soil samples were air dried for 4-5 days. Sieved through sieve of less than 2mm, for soil sample preparation 1 gm of soil passed through sieve of less than 2mm was weighed in electric weighing machine and transferred into clean dried 500 ml conical flask.
10 ml of 1N potassium dichromate solution and 20ml conc. Sulphuric acid was added and mixed by gentle swirling. The flask was kept to react the mixture for about 30 minutes. After the reaction was over, the content was diluted with 200 ml of distilled water and 10 ml phosphorus acid were added which was followed by 1 ml of Diphenylamine indicator. The sample was titrated with 0.4N ferrous ammonium sulphate until the color was changed to brilliant green at the end point. Bulk was run with the same quantity of chemicals but without soil and calculated as follows:

% SOC =3.951/g (1-T/S)
Where,g=weight of soil sample taken in gram.
S=ml (ferrous) solution with blank titrant.
T=ml (ferrous) solution with sample titrant

Soil organic carbon (SOC) = %SOC ×soil bulk density (kg/m3) ×thickness of soil horizon (m) (Kg/m2)
SOC (ton/ha) =soil organic carbon ×10-3(ton)/10-4(ha)

d) Estimation of SOC sequestration rate of BBBZCF:

SOC sequestration rate (ton/year) R = A-B/ Y
R (ton/year/ha) = R/ area of the BBBZCF (ha)
Where, R=SOC sequestration rate (tons/year)
A= amount of soil organic carbon observed in first study (tones)

B= amount of soil organic carbon observed in second study in same plot (tones)
Y= number of years lapsed between two consequent studies in same area.

Statistical tool: excel sheet of MS office was used for all the calculations made in the study.

Results and Discussion

Soil organic carbon

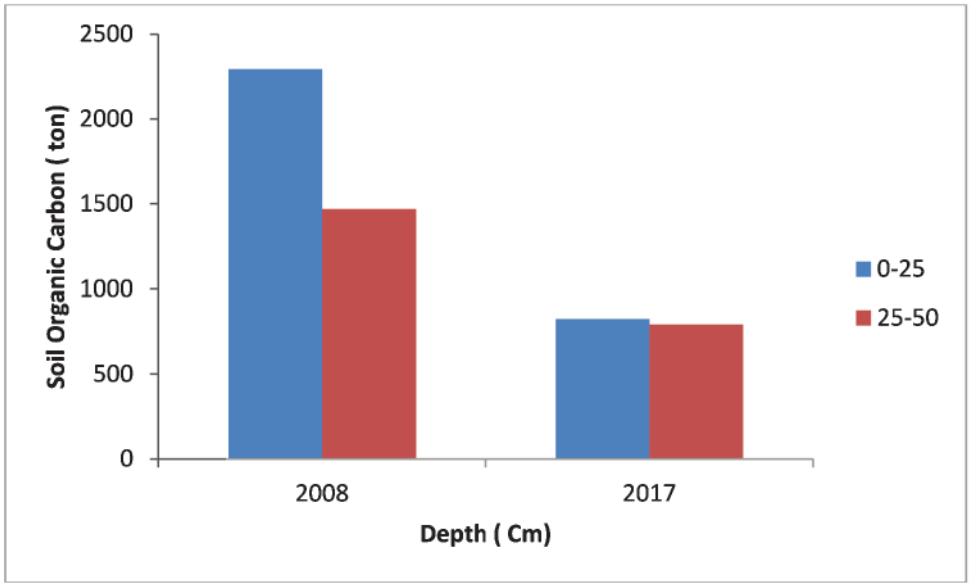

Figure: Showing SOC of two different soil layers for the year 2008 and 2017 BC.

In 2008, total soil organic carbon of BBBZCF was found 3724.75±31.3 tons in 0-50cm layer. Higher level of SOC was found in top 0-25 cm than the lower layer 25-50 cm. It was 2292.74 tons in upper layer and 1468.43 tons in lower layer. In per hectare basis, the 63.37 tons of SOC was recorded from the depth 0-50 cm.

In 2017, total soil organic carbon of BBBZCF was found 1598.63±9.12 tons. Higher level of SOC was found in upper layer than the lower layer. It was 824.23 tons in upper layer and 791.14 tons in lower layer. In per hectare basis, 26.69 tons of SOC was recorded from the depth of 0-50cm.

Total carbon stock of BBBZCF was found as 3724.75±31.3 tons in 0-50cm layer in the study carried out in 2008 BC and the SOC of the same forest was found 1598.63±9.12 tons in the study carried out in 2017 BC. Hence, the SOC sequestration rate of the BBBZCF between two studies was found – 240 t yr-1. (- 4.07t ha-1 yr-1).Carbon has been found lost from forest soils.

Many studies have shown that aggradations of land have positive impact for increasing the SOC level in the soil while degradation of the land has quite opposite effect. In literature review done

by Post et al 1999, it was found when the natural vegetation is cultivated; losses of SOC of as much as 50% in surface soils (20 cm) have been observed after cultivation for 30 to 50 years. Guillaume et al 2015 studied SOC losses after lowland rainforest conversion to oil palm, intensive rubber and extensive rubber plantations in Jambi Province on Sumatra Island, Indonesia. Carbon content in the Ah horizon under Oil Palm and rubber plantation were strongly reduced up to 70 % and 62% respectively. On average converting forests to plantations led to a loss of 10 Mg C ha-1 after about 15 years of conversion. The carbon content of the subsoil found the same and unaffected. The loss of SOC was assumed to due to erosion of top soil and decrease in C input from litter.

Cilek, 2016 studied SOC losses by water erosion in a Mediterranean watershed in Turkey. It was found that soil eroded from the Seyhan River Basin was estimated as 7.8 million tons per hectare (t ha-1y-1). The maximum amount of soil erosion occured in maintenance scrubland and degraded forest areas, contribution to 68 % of erosion followed by that in agricultural land, contribution to 27 % of erosion with the remaining in forest and urban areas.

Sanjuthan et.al., 2018 studied SOC stock changes and GHG emissions following tropical land conversion to plantation crops on mineral soils, with special focus on oil palm and rubber plantation. They found that highest losses occurred when primary forests were converted into cropland (-32 t c ha-1) or perennial plantation crops (-21 t c ha) decrease by -21.5% ± 6% and -18% ± 4% respectively. Low SOC stock losses were observed when primary forests were converted into grassland (-9 t c ha or -1.8 % ± 3%) secondary forests (-8 t c ha or -8.9% ± 2%) . when secondary forests were converted to cropland, grass land or perennial plantation crops SOC losses were lower comparative to the primary conversion to respective land use. The observed SOC losses were primarily due to reduced C input to the soil besides accelerated decomposition after disturbance, although SOC removed by erosion cannot be ruled out, especially when primary forests are converted into land used for annual cropping.

Loss of carbon from the study site was attributed to the following reasons

1) Poor management of the forest: The forest was in poorly managed condition without any management and development plan for the forest. With frequently changing management team and poorly organized CFUG, the forest appears as abandoned. Poor management leads its deterioration by making the forest vulnerable towards illegal felling down of trees, overexploitation of fodder, grazing etc. All these activities contribute in reducing the carbon input in the soils of forest. Hence contributing for SOC loss.

2) Grazing : the barbed wire bounding the forest was broken in many places, from where the domestic animal like cow , buffalo, goats can enter into the forest and graze the herbs and shrubs which could make the portion of SOC. Grazing also expose the soil through stepping of animals, exposed soil could easily eroded by wind and the water.

3) Flood: the forest was flooded 4 years before the study conducted in 2017. During monsoon season the water level of Mahakali River increases and sometime invades into the forest and the nearby village. In 2014, the flood entered into the forest and eroded the top soil which was rich in SOC and leave it with the sand deposition that was carried by the flood water.

Conclusion

It was concluded that the soils of BBZCF has been acting as the source of carbon dioxide and releasing at the rate of 240 tons per year. It would have been acting as the sink for carbon dioxide if the management of the forest was proper and the flood controlling mechanism has been used.

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Status of Human-Snow Leopard Conflict and the Community Practice towards its Conservation Gharapjhong Rural Municipality, 'Ward No. 5' Mustang Nepal

Thakali Sanjog[1], Bhupendra Sharma[2]
1 SchEMS 2 Department of Environment, Correspondence: env_bhupi@yahoo.com

Abstract

Human wildlife Conflict is the interaction between human and wildlife habitat which occur negative impacts by sharing and competing for limited resources. The study was undertaken to analyze the status of animal depredation, investigate the conflict among human and snow leopard. People's perception and practices towards snow leopard conservation has been analyzed.
Primary occupation of the local people is animal husbandry and agriculture in the study area. Due to the climatic and environmental challenges herders are forced to graze in high altitude pasture. Although, other wild herbivorous animals are found, the snow leopards are more attracted towards the domestic animals due to their salty blood and flesh. Livestock is grazed on high altitude grassland in summer season whereas, in winter season they are grazed in near forest areas. Likewise in summer season snow leopard are more active in high altitude and more active in forest area in winter season. Due to the poor design of cowshed Snow leopard frequently attacks livestock by entering inside the cowshed.

Keywords: *Conflict, Grazing, Herders, Livestock, Season.*

Introduction

As old as human civilization the history of human wildlife conflict exists, currently these phenomenon pose serious environmental challenges for human community. Local people have been suffering massive economic losses from wildlife damages which have amplified the aggressive behavior towards them. Population of Snow leopards is diminishing throughout its range due to the habitat loss, declining prey and their widespread persecution (Thapa, 2004). Annapurna Conservation Area, is a part of Nepal Himalaya, ruled by some of the world's highest mountains, supports a significant proportion of Nepal's Snow Leopards estimated at 350-500 individuals (Jackson & Ahlborn 1990).

CITES had registered Snow leopard in Appendix I (NBS, 2002). In Nepal, Snow Leopards are listed in Schedule-1 of the National Parks and Wildlife Conservation Act 1973, which indicates that the snow leopard is the priority species for conservation in national level and internationally. The objective of this research is to analyze the status of animal depredation, understand the seasonality of the animal that leads to the human-snow leopard conflict and the community practice towards its conservation.

Materials and Methods

Study Area:

The study area (Gharapjhong Rural Municipality; ward no 5, Mustang district)lies in Annapurna Conservation Area which is one of the largest protected areas in Nepal. Mountain region are considered as a fragile ecosystem. Due to the less vegetation in this area villagers use high altitude land for grazing where as it is also the habitat of Snow Leopard. Many records of depredation by snow leopard have been recorded.

The research was based on the participatory tools. Primary data were collected through observation, analyzing photographs, focus group discussion, key informant interview and expert consultation. Similarly, additional data were collected by structured questionnaire survey to all stake holders. Furthermore, those data helped to analysis the co-relation of present and the past situation. The data were collected through literature review of various journals, authorized webpage, published and unpublished articles and reports of government, non-government organizations and Annapurna Conservation Area office records. The data are analyzed and interpreted by using a standard Microsoft Excel, Microsoft word as well as, simple mathematical and statistical tool such as pie chart and bar diagrams. Descriptive statistics including Mean, percentage and frequency count were used to describe the age, sex, and education of the respondent.

The total population of Gharapjhong municipality is 1664 whereas, the total population of study area (Ward No. 5) is 685. The total number of household in the study area is 144 (Source: District profile inventory 2073/074), 45 households were taken as sample size however, the total household to be studied as per the sample size formula was 37.930 ≈ 38 house hold.

The Sample size will be determined by: $n = \frac{Z^2 NP(1-P)}{(Nd^2+Z^2 P(1-P))}$

Where,

N= total no of Household = 144
n= sample size
Z= Z statistics for a level of confidence (at 95% Confidence level = 1.96)
P= Estimated population proportion (0.05)
d= Margin of error limit (0.05)

Hence, the sample is 37.930 ≈ 38 (45 house hold sample was taken)

Result and Discussion

The respondents were taken from different age group, sex, educational level and the caste group. Though it is very difficult to know the exact population of snow leopard, somehow the status of population can be identified through the experience of the local people in terms of visualization and the tendency of attacks on livestock.

67% respondents believe that the population of snow leopard has increased in contrary; only 2.2 % people disagreed because they believe that the snow leopard the attack on livestock is same as

the past time, and also stated that killing and smuggling controls the population of Snow Leopard. (49%) respondents agree that Human Snow Leopard conflict is high in this area. Majority of the respondents (64%) Respondents believe that the incidence of livestock depredation in this area is being increased then the past.

As compensation, ACAP provides some amount of money to the victims however, people aren't satisfied with that amount. 75.5% of respondents didn't apply for the relief support the reason behind this are less amount of relief support, difficulties in documentation and time consuming process. The local price of livestock is very high and the amount of relief provided by conservation project is very low that is maximum NRs. 10,000/-; detail is provided in the table 1.

Table 1: Estimated local price of livestock

S.N	Livestock	Local price
1	Goat/Sheep	15,000 - 20,000/-
2	Cow	8,000 - 15000/-
3	Donkey	50,000 – 80,000/-
4	Jhopa/Local cow	40,000 – 70,000/-
5	Horse	60,000 – 1,00,000/-
6	Yak	90,000 – 1,40,000/-

Generally, livestock are grazed freely on high altitude grassland in summer season (presence of green and fresh grass in high altitude) whereas, in winter season they are grazed nearby forest (the high altitude area are covered by snow), and so on in summer season Snow leopard are more active in high altitude and in forest area in winter season. As a result, Snow Leopard possesses threats to domestic animals in all season.

Most of the herding communities are against the conservation of Snow Leopard due to the massive loss of livestock. However, nowadays people are being positive to the conservation of Snow Leopard due to the tourism, cultural and religion aspect. In order to protect the livestock, the villagers take many precautionary measures such as hiring herder (29%), making fence or cowshed (47%).

Table 27: Livestock Depredation by Common/Snow Leopard and a Relief Support by ACAP

S.N	Livestock-species	No. of animal killed	Date of attack (D/M/Y)	Owner Name	Village	Relief Support	Predators
1.	Horse	1	14/11/2014	Lote Gurung	Muktinath-4, Jharkot	10,000/-	Snow Leopard
2.	Horse	1	18/03/2015	Chhwang Nyamgya Gurung	Muktinath-8, Khinga	10,000/-	Snow Leopard
3.	Horse	1	02/04/2015	Chhiring Dorje Gurung	Jomsom-4, Thini	10,000/-	Snow Leopard
4.	Horse	1	10/04/2015	Chhiring Dorje Gurung	Jomsom-4, Thini	10,000/-	Snow Leopard

5.	Horse	1	08/05/2015	Chhiring Gurung	Kagbeni-8,k-agbeni	10,000/-	Snow Leopard
6.	Horse	1	22/06/2015	Gam Bahadur Gurung	Jhong-3, Chhengur	10,000/-	Snow Leopard
7.	Goat	1	26/06/2015	Shaymlal Gurung	Jomsom-9 Dhumba	2,000/-	Snow Leopard
8.	Horse	1	11/08/2015	Kunsang Gurung	Jomsom - 5, Jomsom	10,000/-	Snow Leopard
9.	Horse	1	20/09/2015	Mangun Thakali	Jomsom - 2, Thini	10,000/-	Snow Leopard
10.	Sheep	11	22/09/2015	Aaita Thakali	Jomsom- 4 Thini	10,000/-	Snow Leopard
11.	Goat	2	14/02/2016	Ratna lal Gotame	Jomsom-8 , Jomsom	2,400/-	Snow Leopard
12.	Sheep	3	05/03/2016	Shing Raj Gurung	Marpha -9 , Chhairo	6,000/-	Snow Leopard
13.	Yak	1	18/05/2016	Gautam Sherchan	Kobang-8,Ko-bang	8,000/-	Common Leopard
14.	Yak	1	19/05/2016	Shyam Tamang	Kobang-3, Nakung	8,000/-	Common Leopard
15.	Goat	2	20/06/2016	Thamlal Mijar	Kobang -5, Kobang	4,000/-	Common Leopard
Total		**29**				**1,20,400/-**	

The table 2 shows the record of animal killed by Common/Snow Leopard, which was recorded in ACAP. The record was kept according to the application of victims who applied for the relief support. It is necessary to note that all the data were taken from the entire area of the Mustang district. In total only 29 killed livestock had recorded in ACAP similarly, the total amount of relief fund provided by ACAP was Nrs 1, 20,400/-.

Table 3: Livestock depredation of Respondents by Leopard

S.N	Owner Name	No. of animal killed	Date of attack (Y/M)	Livestock species	Attack area	Losses in terms of money (In Average, NRs)	Remarks
1	**Tik Prd Thakali**	1	2074/06	Jhopa	Namu Grassland	65,000/-	Not applied
2	**Purna Thakali**	2	2073/01	Goat	Thini, at home	11,000*2 =22,000/-	Not applied
		11	2072/08	Goat	Thini, at home	10,000*11=1,11,000/-	From ACAP 10,000/-
		1	Unknown	Horse	Way to tilicho lake	50,000/-	Not given

3	Bishnu Gurung	1	2071/03	Jhopa	Kaisang grassland	45,000/-	From ACAP 7,000/-
		2	Unknown	Goat with young goat (2 years)	Thini, at home	20,000/-	First attack in Thini
4	Mankari Thakali	2	2071/02	Sheep	Thini, at home	17,000/-	From ACAP 2,500/-
5	Kemi Thakali	1	2071/05	Cow	Bhudi thang	8000/-	Not applied
6	Sukmaya Thakali	1	2071/12	Cow	Thini, at home	4000/-	Not applied
7	Nima Gurung	2	2071/12	Jhopa	Samle Jungle and Chyama lake	66000 + 45000= 1,11,000/-	Not applied
8	Buddibal Thakali	2	2070	Horse with child of 1 years	Chyama Lake	75000+30,000= 10,5000/-	Not applied
9	Laxmi Thakali	1	2070/09	Cow	Thini, at home	7000	From ACAP 2,500/-
10	Deblal Thakali	1	2070/09	Horse	Thini, at home	30,000/-	Not applied
		2	Unknown	Sheep	Thini, at home	15000/-	Not applied
11	Mukti kumai	3	Unknown	Cow	Fyangthang	3*5000=15,000/-	Not applied
Total		33					22,000/-

Although many conflicts and misunderstanding arises among Snow Leopard and villagers, majority of people expressed a positive attitude towards the snow leopard conservation which is 67% (30). Similarly 13% (6) of respondents are totally against it.

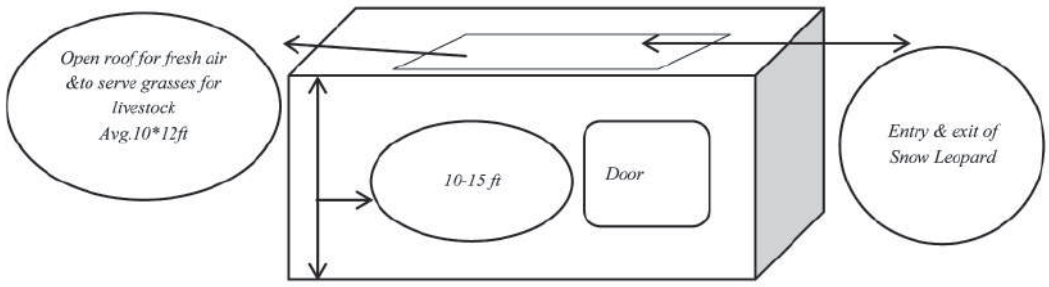

Figure 1: Local design of cowshed

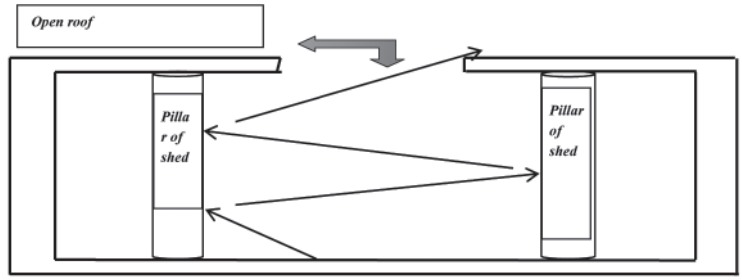

Figure 2: Entry and Exit of Snow leopard in Cowshed

Due to the poor design of cowshed (figure 1) it is found that in winter season Snow leopard frequently attacks livestock by entering inside the cowshed. In average the area of the cowshed is 30*40ft. The roof of the cowshed is open which acts as a Ventilation and serving grasses for the livestock.

In average, the area of open roof of the cowshed is 10*12ft (figure 2). This open roof is the weakness of the cowshed because via the open roof snow leopard can enter and exit easily by killing livestock. The respondent's cowsheds overall measurements are relatively same As shown in the figure 2 above the Snow Leopard directly jump inside cowshed and kill the livestock. However, to go outside they use the pillar of cowshed as ladder; they climb over pillar in crisscross way by which they can easily escape out of the shed. This type of movement is analyzed by the evidence found in cowshed such as mark of claws and also by the interview with owner of the killed animals.

Snow Leopard is the most important species and the top level predators of the mountain ecosystem which helps to balance the environment and ecosystem in mountain region. In support to present study research done in Mustang, the depredation rate of total livestock by snow leopard was, 6.6% (Ale et.al, 2014). As well as the study in Manang (Annapurna Conservation area) shows that overall depredation rate is 2.6% (Oli, 1991).

The winter season was recorded as a highest depredation season (44%), followed by summer (40%). This seasonal variation in livestock depredation is similar to the study conducted in Annapurna Conservation Area of Manang (Oli, et al., l99l) where it was found that 42% losses occurred during winter and 15% in summer and autumn.

In recent years the competition for existence has converted into conflict and has threatened to destroy the natural balance and right of wildlife to co-exist in many areas of Nepal (Giri and Shah, 1992).Similarly, the NRCA and other key informants reveals that the other predators like; Leopard cat, feral dog had also depredated the animals specially the babies of animals. The large number of goats and sheep are killed by snow leopard because they are easier to hunt in comparison to the wild animals. The traditional belief of the villagersis that snow leopards are more attracted towards domestic animals because of feeding salt regularly to livestock by which their flesh and blood gets more salty taste and easy to hunt than other wild herbivorous animals.

The traditional system of grazing and the construction of shed with poor design are the weak points of the herding family. 67 % of the total depredated livestock had been killed in home shed due to the poor design of the shed. Interviews with Key-informants reveal that local people had a positive attitude towards the blue sheep but a negative attitude toward the snow leopard in Mustang District of Nepal (Ale et al, 2014) which is quite different to this finding; 67% of the respondents had expressed a positive attitude towards the snow leopard conservation. In order to support the conservation of snow leopard; local people, students and other stakeholder of this area had celebrated the first and second 'International snow leopard day' in Mustang district. As well as, an ancient cave was remunerated and named as 'Snow leopard cave' by the local youth club "Janamukti Yuba Club" (JYC) dedicating to the endangered animal Snow Leopard. Currently this

becomes the famous tourism spot in Gharapjhong Rural Municipality, Mustang.

Conclusion

Interactions with the locals has helped to conclude that the leopard is one of the prominent predators which is mostly responsible for the killing the domesticated animals either in high altitude or in village cowshed. Thini village is the most prone area for the attack of the Snow Leopard. Conservation project appears to have a less record of depredated domestic animals then it actually happens in the study area. In fact, the record was maintained on the basis of application submitted by the victims for support relief fund. Maximum amount of relief support provided by the project is NRs. 10,000/- whereas the actual price is much higher.

13% of the herding families are against the conservation of Snow Leopard due to the massive loss of livestock. Although many conflicts and misunderstanding persist between Snow Leopard and villagers, majority people expressed a positive attitude towards the snow leopard conservation which is 67% (30). The key informants had stated that the snow leopard has a mass killing nature and drinks blood after they kill the livestock. Nevertheless, the assumption may not be absolutely accurate. The mass killing may take place when snow leopard gets terrified while struggling to escape from the shed and also by the random movement of the horrified livestock, so the snow leopard might kill whoever comes in his way.

Snow leopard kills either with a nape or throat bite, which creates suffocation due to the throat bite and can be known by the specific bite marks on the throat (Fox, 1989). Along with these key informants also believe that snow leopards have the tendency to suck the blood and leave the body, however the facts maintained that animals of cat family are flesh eater.

Recommendation

Based on the research, result and findings of field study the following mitigation measures and recommendations are suggested:

- The hotspots of livestock depredation should be recognized and GIS maps should be developed to avoid the high risk areas for herders.
- Especially focusing on female, herders, youths and nomads, conservation related workshop, training and awareness program such as the role of snow leopard plays in balancing the ecosystem by acting as the supreme predators should be given which, helps to bring the positive attitude towards the conservation of snow leopards and their habitat.
- Construction and maintenance of predator proof corrals and combined cow shade should be encouraged which helps to mitigate the livestock depredation.
- Electronic instrument like Fox light should be provided for herders. Fox lights are the flashing lights that scare the Snow Leopards away from corral and those lights helps to minimize the livestock depredation and conflict among leopard and human.
- Poor design of the local cowshed is also one of the major causes of depredation in cowshed. Hence, the design of the local cowshed (blocking the open roof) should be modified which helps to halt the snow leopard from entering cow shed and cause livestock depredation.
- Conservation project should increase the relief support which helps to overcome the losses

caused by animal depredation. As well as the conservation project should encourage the local people to follow the proper methods of guarding their livestock against the predation of the leopards.

- Regular Monitoring and evaluation should be done by which it helps to make the concerned authorities well aware on the extent of human – snow leopard conflict levels and assist in making some special arrangements to reduce the conflict.

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Assessing river water suitability for strawberry irrigation: a case study of Kolpu Khola watershed in central Nepal

* Prava Pandey[1], Vishnu Prasad Pandey[2], Deepak Wagle[3]
[1] National Lake Conservation Development Committee/Ministry of Culture, Tourism and Civil Aviation, Government of Nepal
[2]International Water Management Institute (IWMI), Nepal-Office, Kathmandu
[3] Trinity International College, Dillibazr Height, Kathmandu, Nepal
* Corresponding Email: prabhapandey2012@gmail.com

Abstract

This paper analyzes river water quality in Kolpu Khola watershed, a rural watershed located at Okharpauwa area in Nepal to evaluate its seasonal variations as well as suitability for strawberry (an important cash crop in the area) irrigation. For the evaluation, a set of selected water quality parameters were analyzed. Water samples were collected during pre-monsoon (March) and post-monsoon (October) seasons in 2008. Water quality was characterized based on twelve water quality parameters and four other indices. A guideline for suitability analysis was prepared by review of relevant literatures. The evaluation with reference to the guideline indicates that the river water in the study area is suitable for strawberry irrigation.
This study, along with analyzing suitability of river water for irrigation, also contributes by documenting water quality information of a small-sized rural watershed in central Nepal.

Keywords: *Kolpu Khola watershed, Okharpauwa, strawberry, irrigation water quality.*

Introduction

The Kolpu Khola watershed (area =11.6 km2) lies between 27°46'20"-27°49'07"N latitudes and 83°13'34"-85°16'23"E longitudes (Fig. 1). It is located at a distance of about 25 kilometers north-west of Kathmandu (the capital city of Nepal). The area is popular as the largest strawberry farm in Nepal. The farms were emerged after JAITI Nepal's researches in a pilot farm concluded the area's suitability for varieties of strawberries about two decades ago (Nepal 2004). Owing to its sweetness and high yield, the strawberry has been a popular high value cash crop and backbone of local economy in the area. Currently, more than 700 households in the area are involved in commercial farming; each producing approximately 1,000 kilograms (kg) of strawberries per season (Rana 2010). The Okharpauwa area has been an ideal location for varieties of strawberries cultivated in Nepal which require an altitude of 1,500-2,500m with a temperature range of 4-25ºC and more than 2,500 mm of rainfall (Rana 2010). Because the area has altitude of 1,600-1,800m, mean monthly temperature of 8.5-19.3ºC and receives 2,907 mm/year of rainfall in an average; with 80 % of that falling during rainy season (Jun-Sep) (source: 1987-2006 data analysis at Kakani station). Due to unavailability of adequate rainfall at the time the crop needs, providing supplementary irrigation from river water is unavoidable. In the area, water from four streams within Kolpu Khola watershed namely Kule Khola, Chitre Khola, Kaule Khola and Khani Khola (please refer to Fig. 1) a re being used to irrigate the strawberry farms.

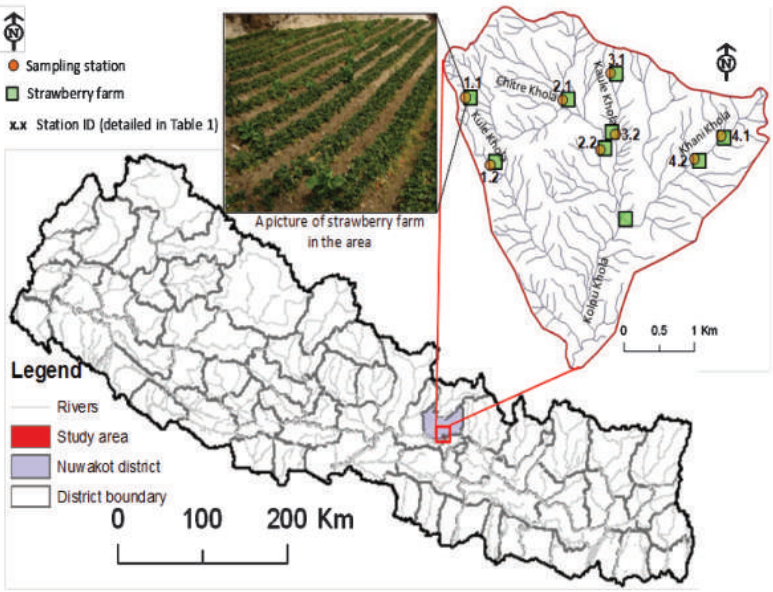

Figure 1 Location of Kolpu Khola watershed and sampling stations in central Nepal.

Materials and Methods

Sampling and analytical methods

The data were collected by on-site testing, laboratory analysis and relevant secondary data acquisition. Firstly, the strawberry farms were located in topographic map and cross-checked by reconnaissance survey during 13-15 February, 2008. More information was collected by consulting related experts, local people, literatures (e.g., Baral 2001, Dhimal 2002, Gotame 2005) and map of the study area. Water samples were collected in pre-monsoon (March) and post-monsoon (October) seasons in 2008. The samples were collected from eight stations (shown in Fig. 1 and detailed in Table 1). Two stations along each of the four streams - Kule Khola, Chitre Khola, Kaule Khola and Khani Khola - in the watershed were selected on the basis of amount of water diverted for irrigation. Plastic bottles of different sizes (500/1000ml) were used to collect the water samples. The bottles were first rinsed with respective water samples and then filled air tight.

Table 1 Details of sampling stations

Station ID	Lat(N)	Long(E)	Altitude(m)	Remarks
1.1	27°48'09"	85°13'34"	1750	Kule Khola stream, have minimum human interference
1.2	27°48'00"	85°13'41"	1600	
2.1	27°48'54"	85°14'02"	1800	Chitre Khola stream
2.2	27°48'15"	85°14'11"	1730	

3.1	27°48'43"	85°15'10"	1770	Kaule Khola stream
3.2	27°48'35"	85°15'17"	1680	
4.1	27°48'50"	85°16'14"	1730	Khani Khola stream, have maximum human interference as compared other sites
4.2	27°48'30"	85°15'35"	1640	

The pH and electricity (EC) were recorded on the site by pH meter and conductivity meter. Other parameters such as total dissolve solids (TDS), chloride (Cl), nitrate (NO3-N), total hardness, calcium (Ca), magnesium (Mg), total alkalinity; sodium (Na) and potassium (K) were analyzed following standard guidelines and procedures (Vogel 1961, APHA et. al 1998) in the laboratory. The TDS was calculated by filtration technique (using Whatman's filter paper number 42). Chloride, total alkalinity, total hardness and calcium hardness were analyzed by titration method and magnesium hardness by subtracting calcium hardness from total hardness in the same volume of sample. Sodium and potassium was calculated by flame photometric method. And, nitrate (NO3-N) was determined by phenol disulfonic acid method. Each analysis was done in triplicate and the mean value was taken. The analytical data quality was ensured through careful standardization, procedural blank measurement and repeated analyses.

Data treatment and analysis

Firstly, water qualities at two stations in the same stream were averaged to discuss the state of water quality in all the four streams. To represent water quality of the whole watershed under study, the mean value of the four streams were taken. Salt content such as chloride and calcium and magnesium hardness were calculated as milli-equivalent per litres (meq/l) by dividing the value in mg/l by equivalent weight. Sodium absorption ratio (SAR), sodium percentage (Na%), residual sodium carbonate (RSC) and permeability index (PI) were calculated following equations 1-4 to evaluate the water's suitability for irrigation.

Sodium absorption ratio; $SAR = \frac{Na}{\sqrt{\frac{Ca+Mg}{2}}}$ … … (1)

Sodium percentage; Na% = [(Na + K)/(Ca + Mg + Na + K)]*100 … … (2)
Residual sodium carbonate; RSC = (CO_3 + HCO_3) – (Ca + Mg) … … (3)
Permeability index; PI = [{Na + (HCO_3) 1/2} / (Ca + Mg + Na)]*100 … … (4)
where all the concentrations are in meq/l.
The suitability for irrigation was evaluated following a guideline presented in Table 2. The guideline is the modified version of the original one from Ayers and Westcot (1994), which is widely used in the irrigation water suitability analysis (e.g. Marini and Piccolo 2004, Mekonnen 2007, Dimitrov et al. 2008, etc.). Modification was made by merging information suggested in other guidelines.

Potential Irrigation Problem	Units	Degree of Restriction on Use		
		None	Slight to Moderate	Severe
Salinity hazard (affects crop water availability)				
EC	µS/cm	< 700	700-3000	> 3000
TDS	mg/l	< 450	450-2000	> 2000
Infiltration (affects infiltration rate of water into the soil. Evaluate using permeability index.)				
Permeability Index (PI)[1]	-	> 75	25 - 75	< 25
Sodicity or Na hazard (affects by clogging soil pores and reducing permeability)				
SAR	meq/l	< 3	3 - 9	> 9
Na%[2]	%	< 60	60 - 80	> 80
Chloride (Cl) hazard (toxicity)	meq/l	< 4	4 - 10	> 10
Nitrogen (NO_3-N) hazard (An excess results over-stimulation of growth, delayed maturity, poor quality)	meq/l	< 5	5 - 30	> 30
pH	-		Normal Range 6.5 - 8.4	
Residual sodium carbonate (RSC)[3]	meq/l	< 1.25	1.25 - 2.50	> 2.50

Table 2 Guidelines to assess suitability of water quality for irrigation (adopted and modified from Ayers and Westcot 1994)

[1]Restriction level values from Doneen (1964) with the names of the levels slightly modified;
[2]Restriction level values from ISI (1974) with the names of the levels slightly modified;
[3]Restriction level values from US Salinity Laboratory (1954) with the names of levels slightly modified.

Results and discussion

Variation in water quality over locations and seasons

The descriptive statistics of twelve water quality parameters analyzed in this study are shown in Table 3 and details for the four streams are shown in Table 4. The tables show that water quality varies with locations and seasons; with pre-monsoon having higher concentrations compared to the post-monsoon. The differences in mean values are generally higher for EC, TDS and Hardness and lower for Ka, Na, Mg and Ca. Statistical tests for significance were not applied as the numbers of samples were fewer for each season. Water quality in Khani Khola is relatively worse compared to other streams because of high degree of human interference than other streams.

Table 3 Descriptive statistics of water quality parameters during pre- and post-monsoon seasons in the study watershed

Parameter	Unit	Pre-monsoon				Post-monsoon			
		Min	Max	Mean	Std. dev	Min	Max	Mean	Std. dev
pH	-	7.40	7.90	7.68	0.19	7.20	7.50	7.38	0.12
EC(at 25°C)	µS/cm	23.00	55.30	35.10	13.01	18.50	50.70	29.73	13.52

Cl	meq/l	0.61	0.66	0.64	0.02	0.52	0.59	0.56	0.03
TDS	mg/l	15.00	36.00	22.83	8.50	12.00	33.00	19.33	8.81
HCO_3	meq/l	0.27	0.66	0.44	0.16	0.21	0.52	0.33	0.13
Hardness	mg/l	11.10	16.85	13.71	2.09	8.70	14.25	10.62	2.35
Ca	meq/l	0.11	0.20	0.15	0.04	0.06	0.17	0.11	0.04
Mg	meq/l	0.11	0.14	0.13	0.12	0.06	0.11	0.09	0.02
Na	meq/l	0.15	0.27	0.20	0.47	0.10	0.24	0.16	0.05
K	meq/l	0.01	0.07	0.04	0.24	0.01	0.04	0.02	0.02
NO_3-N	mg/l	2.70	4.70	3.52	0.76	2.46	4.00	3.01	0.64
SAR	meq/l	0.41	0.67	0.54	0.11	0.33	0.63	0.47	0.12
Na%	%	45.21	48.62	46.36	1.53	43.89	49.70	46.47	2.41
RSC	meq/l	0.02	0.32	0.16	0.15	0.04	0.24	0.10	0.09
PI	-	159.38	205.73	179.72	19.23	184.06	222.08	199.94	16.20

In addition to 12 water quality parameters, some other indices of water quality (i.e., SAR, Na%, RSC and PI) were also calculated to analyze level of several hazards related to the use of irrigation water. The indices also varied over the locations and seasons (Table 3 and 4). However, they are within the safe range that poses no threat to the soil and crop quality.

Table 4 Water quality of the four streams in the study area

Parameters	Unit	Pre-monsoon season				Post-monsoon season			
		1	2	3	4	1	2	3	4
pH	-	7.70	7.80	7.90	7.40	7.40	7.50	7.50	7.20
EC (at 25°C)	µS/cm	29.00	23.00	25.00	55.30	20.00	20.00	18.50	50.70
Cl	meq/l	0.66	0.61	0.65	0.63	0.53	0.52	0.59	0.58
TDS	mg/l	19.00	15.00	16.00	36.00	13.00	13.00	12.00	33.00
HCO_3	meq/l	0.51	0.28	0.27	0.66	0.27	0.21	0.22	0.52
Hardness	mg/l	13.50	12.85	11.10	16.85	9.00	8.70	8.80	14.25
Ca	meq/l	0.14	0.11	0.11	0.20	0.12	0.06	0.09	0.17
Mg	meq/l	0.13	0.14	0.11	0.13	0.06	0.11	0.08	0.11
Na	meq/l	0.15	0.20	0.17	0.27	0.10	0.14	0.13	0.24
K	meq/l	0.07	0.01	0.04	0.01	0.04	0.01	0.04	0.01
NO_3-N	mg/l	3.24	2.70	3.10	4.70	2.58	2.46	2.54	4.00
SAR	meq/l	0.41	0.57	0.51	0.67	0.33	0.48	0.45	0.63
Na%	%	45.21	45.65	48.62	45.98	43.89	45.86	49.70	46.42
RSC	meq/l	0.24	0.02	0.05	0.32	0.09	0.04	0.05	0.24
PI	-	205.73	159.38	175.67	178.10	222.08	193.29	200.35	184.06

1, 2, 3 and 4 represents Kule Khola, Chitre Khola, Kaule Khola and Khani Khola respectively.

Suitability of the Water for Irrigation: Suitability of the river water for irrigation depends upon the mineral constituents present in the water. In this study, the suitability for irrigation is evaluated with reference to the guidelines shown in Table 2.

With reference to Salinity: Salinity in the river water refers to the total soluble salt and is expressed/measured as either EC or TDS. Maximum values of the both the EC and TDS in Kolpu Khola watershed are very low (EC = 55.3μS/cm and 50.7μS/cm and TDS = 36.0mg/l and 33.0mg/l in pre- and post-monsoon seasons respectively) (Table 3) compared to the restriction level for irrigation shown in Table 2. Therefore, the water is suitable for irrigation purpose from the perspective of salinity hazard.

With reference to Infiltration/permeability: The soil permeability is affected by long term use of irrigation water containing sodium and bicarbonate. Infiltration rate of water to the soil is affected if sodium reacts with soil and clogs the particles (Todd 1980, Nagaraju et al. 2006). The potential irrigation problem related to the infiltration can be evaluated based on Permeability Index (Doneen 1964) shown in equation-4. In the study area, the minimum value of PI is quite above the restriction level for use (Table 3 and 4). It suggests that the water is suitable for strawberry irrigation from the perspective of infiltration hazard.

With reference to Sodicity or Na hazard: The Na replacing adsorbed Ca and Mg is a hazard as the reaction of Na with soil results clogging of particles, thereby making it compact and low permeable (or even impervious) (Kelly 1951, Todd 1980, Nagaraju et al. 2006) and excess Na in irrigation water enhances the hazard. The Na hazard is usually evaluated based on two sodium related indices, namely, sodium adsorption ratio (SAR, equation-1) and sodium percentage (Na%, equation-2). The value of SAR in the water samples varied from 0.41 to 0.67 in pre-monsoon and 0.33 to 0.63 in post-monsoon seasons. The Na%, on the other hand, were found to vary from 43.9 to 49.7 in both pre- and post-monsoon seasons (Table 3); indicating no restriction for irrigation use. These results confirm the suitability of the river water for irrigation with respect to sodium hazard.

With reference to Chloride hazard: Cl is a most common toxicity as it is neither absorbed nor held back by soils. The crop could take it up and accumulate in the leaves. If the concentration levels in the leaves exceed the tolerance level of the crop, injury symptoms like leaf burning of leaves or drying of leaf tissues may develop. Since the Cl concentration in the water samples from the study area are well below the restriction level for irrigation use shown in Table 2, the water is free from chloride hazard.

With reference to Nitrogen (NO3-N): Nitrogen in irrigation water has much the same effect as that of fertilizer nitrogen. An excess will cause problems just as too much fertilizer would, for example, over-stimulation of growth, delayed maturity or poor quality. The nitrogen concentration in the form of nitrate (NO3-N) in the sample waters is very low, varying from 2.7 to 4.7 mg/l. This indicates that the water is free from NO3-N hazard.

With reference to pH: If the pH value is outside the normal range of 6.5 to 8.4 (Table 2), it may cause a nutritional imbalance or may contain a toxic ion. The pH of the river water in the area, though slightly alkaline in nature in both pre- and post-monsoon seasons, is within the normal range. It implies, according to Ayers and Westcot (1994), that there is no alkalinity hazard, therefore, the waters are suitable for irrigation purpose with reference to pH.

With reference to RSC hazard: The RSC (equation-3) indicates carbonate level in water assuming that concentration of bicarbonate and carbonate also influences the suitability of water for irrigation. The RSC significantly influence the pH, EC and SAR of the irrigation water. RSC values for all the water samples were found to be less than 1.25 meq/l, indicating suitability of the water for irrigation with respect to the RSC hazard. This is due to low amount of total carbonate levels exceed the low amount of Ca and Mg and the water quality may have not been diminished.

Though the water quality can be classified and evaluated based on some established guidelines (e.g. in Table 2), it should be noted that the classifications are indicative guidelines only. Their application will have to be adjusted to conditions that prevail in the field. This is because the conditions of water use in irrigation are very complex and difficult to predict. The suitability of water for irrigation will greatly depend on the climatic conditions, physical and chemical properties of the soil, the salt tolerance of crop grown and the management practices. Thus, classification of water for irrigation will always be general in nature and applicable under average use conditions.

Conclusions

Results of this study showed that the river water quality in the study watershed varies with locations and seasons; with pre-monsoon having higher concentration compared to the post-monsoon. The suitability analysis showed that the river waters are free from general hazards (e.g., salinity, infiltration, sodicity, chloride, nitrogen, alkalinity/acidity, and NO3-N) and are suitable to irrigate strawberry in the Kolpu Khola watershed of Okharpauwa area in central Nepal. Further strengthening in irrigation facilities may increase the strawberry yield in the area provided that the irrigation water is applied considering local conditions.

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Impact Assessment Of Flood Hazard In Babai River, Buffer Zone Of Bardiya National Park

TrilochanSubedi*
*M.Sc. in Environmental Management,
Corresponding Author: greentrisubedi@gmail.com

Abstract

Natural disaster flood is one of the striking water induced disasters that hits Terai region as a serious disaster. The study describes the impact of flood hazard on property and agriculture. It also describes the technical approach of problem of flood hazards analysis and relation between stream flow and property losses, agriculture and contribution of Rainfall on flood. During the study the effectiveness of DEOCis also analyzed. Weibull equations used to calculate a return period of different scale flood discharge.

The analysis showed that 411.13 ha cropland, 26.4 hectare of settlement, 20.1626 hectare grass land and 8707 meter road is likely to affected more by 20 years return period. Therefore the impact assessment of flood hazard in this study provides information about losses on property and agriculture with stream flow and frequency of flood with spatial reference to extreme historical flood, for flood damage assessment.

Key words: *Flood, DEOC, Weibull equation, Hazard, impact of flood*

1. Introduction

Flooding is the most frequently occurring disaster in the world (Jonkman, 2005).Flood is a natural event or occurrence where a piece of land or area that is usually dry land, suddenly gets submerged under water (Gasim,et.al,2006).Seasonal floods are the main problem in the Babai River, Buffer Zone of Bardiya National park. Every year, the community and people face many challenges, losses property, settlement, Cattle and many more. DDRC make a different management plan and invest lots of money for flood hazard control, reduce damages and losses. Many works were done and make a plan by DEOC & DDRC but the exact data and exact effectiveness is not studied yet. The study focus to analyze the impact of flood on settlement and agriculture and other properties, effectiveness and impacts of management work and investment by DEOC and its impact, effectiveness in Thakurbaba municipality ward no 4.

2. Materials and Methods

2.1 Study area

The Babai River originates in and completely drains inner Terai Dang Valley of mid-western Nepal. The Babai starts from the eastern end of Dang valley at 27°58'27"N 82°34'06"E Over 1400 people living in the area(Census 2011), many of them farmers were removed to provide a greater area for the abundant species within the park. Each year, floods of varying magnitude occur due to intense, localized storms during the monsoon month (June to September) in study area of Babai buffer zone of Bardiya National park. The catchment area at outlet is 2602 km2.Annual average discharge at outlet side is 71m3/s with maximum and minimum monthly discharge being 588m3/s

and 4m3/s respectively. The estimated mean annual rainfall of Babai basin is 1156 mm where the highest annual rainfall recorded at Nayabasti station (Yadav, 2002). Out of the 94(census 2011) wards 4 wards of Bagnaha (ward no 4 of Thakurbaba municipality) (2017) are included in Barbardiya municipality. There are 125 villages in the buffer zone of Bardiya national park. Out of the total area the buffer zone area is about 507 sq. km. The water discharge in the Babai River is very high in the rainy season in the other season the river is mainly dry. The 2,3,7,9 area has mainly a sub-tropical monsoonal climate with summer from mid-June to early October followed by a relatively long, cold dry winter. Temperature variation is high ranging from 10°c to Sometimes peak up to 45°c with an average temperature 35°c (Bam, et.al 2013). There are three distinct season, hot-dry season from February to mid-June. Monsoon from mid-June to early October, and cold dry season from early October to February (BNPMP 2016) Flood is the one of the major problem in the study area, in the past year 2015 around 700 household were inundated by flood. Squatter's settlements, Study area and other nearby areawereincluded in this data.Also in the recent year 2017 many people losses their family, Land, settlement and crops by flood.

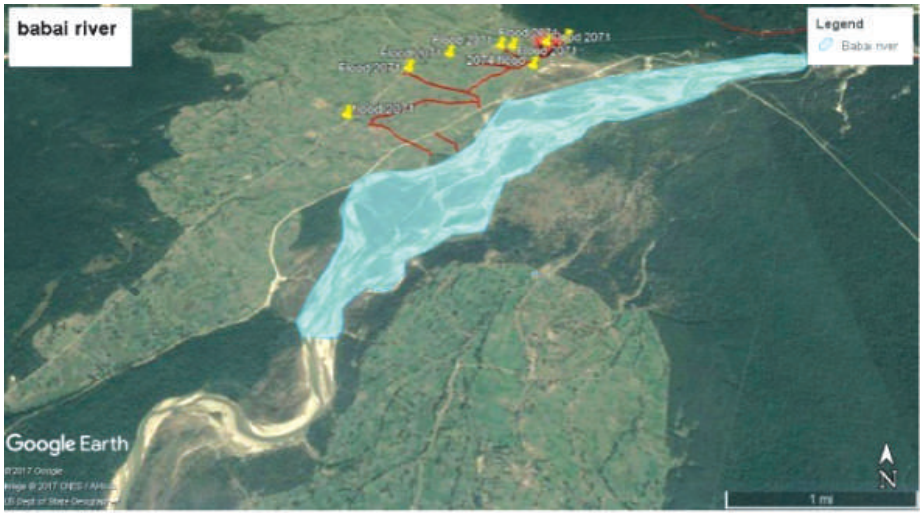

Figure 1: BabaiRiverFigure

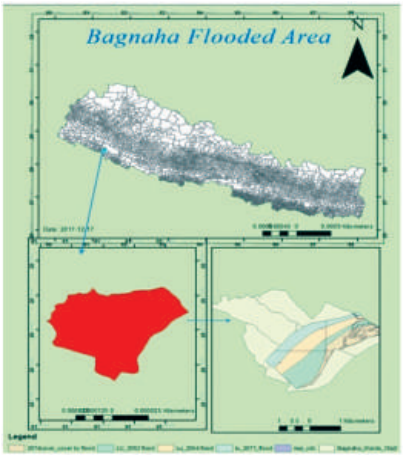

Figure 2: Study Area

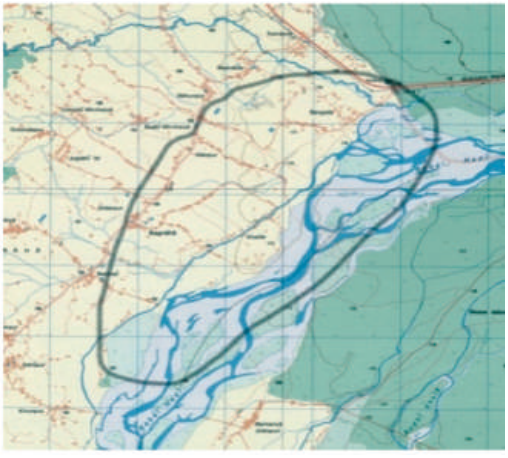

Figure 3: Topographic Map of Study Area
Source: Department of Survey

2.2 Data collection

Study was carry out in Thakurbaba municipality ward no 4 (Bagnaha V.D.C. ward 2, 3, 7, 9) and surrounding buffer zone of Bardiya National Park. Public survey was carried out at Thakurbaba municipality ward no 4(Bagnaha V.D.C ward 2, 3, 7, 9). The different management plan was made DEOC, DDC to control and to minimize the losses by flood. Every flooded year district and this area loosed lots of property and Agriculture. DDC invest about 2189500 rupees for training and capacity building to minimize the losses and damage by disasters like flood. In 2071 about 374 houses were fully affected by flooded and 2022 people were displaced and about749 houses were partially affected by flood but in 2074 about 18 houses were normally affected this is due to construction of Dam on Babai river (i.e. near the area of ward no 4 of thakurbaba municipality). The study tried to analyze the impact of flood on Property and Agriculture &effectiveness of DEOC and collect the necessary data for research.

2.2.1 Hydro-metrological Data : The 25 years yearly monthly average Data of Stream flow on Babai River measured from nearest station (Chepang) was collected from Department of hydrology and metrology. The stream flow was used for the flood frequency Analysis, temperature data to analyze the spatial distribution of temperature in the study area and the rainfall data to analyze the contribution of rainfall in flood.

2.2.2 Topographic Map : Digital copy of topographical map of study area sheet number 2881 10A (Scale 1:25000) was collected from the Department of survey, Kathmandu. This was use for field observation and flood area calculation.

2.2.3 Public Survey : It is basic for the assessment of people's perception on flood, management plan and activity of DEOC, DDC and municipality. The questionnaire survey was carried out in different local people and mayors of thakurbaba municipality.

2.2.4 Field observation : A field observation was carried out in Babai River, buffer zone area of the Bardiya national park to collect the data of flood and its impact and damages onsept-Oct. (2017). The study aimed to know the problem, status of river and assess the loss and damages. The observation around the buffer zones was also basically aim to identify adaptation measures apply by local if any.

2.2.5 Secondary Data Sources : Publication, report ,book, literature from different source related to the study like college library, TU library, Department of National park library, Central bureau of statistics, Department of survey, Department of metrology and hydrology and Worldwide wave through internet , Google earth has also used as a secondary source of data to calculate the area affected by flood and spatial extent map will export as kmz file for ArcGIS 10.4, Land use map prepared by department of survey from 1985-1990 is used.

2.2.6 Sample/ direct observation

The Sample size wil be determined by : $n = \frac{Z^2NP(1-P)}{(Nd^2+Z^2NP(1-P))}$

Where N= total no of Household (1082)

n= sample size
Z= Z statistics for a level of confidence (at 95% Confidence level = 1.96)
P= Estimated population proportion (0.05)
d= Margin of error limit (0.05)

The sample size for the study area was found to be 68. The study area has mix-community of ethnicity and varying level of socio-economic classes so the households were selected by using stratified random sampling techniques.

Some information and data were collected by direct observation during field visit and questionnaire survey. Ocular inspection and the On-site photography were also used to know about the affected area by flood.

2.3 Analysis Method

2.3.1 SPSS/ Excel : The data obtained from questionnaire survey was analyzed from thespss/ excel and from these data we can make a recommendation and conclusions. The collected the data from 68 households in Thakurbaba municipality ward no 4, which is analyzed from Excel and SPSS.

2.3.2 ArcGis 10.4 : The land use data obtained from the department of Survey was analyzed and calculated the area of different field from ArcGIS 10.4. And Google earth pro is used to locate the flooded area and identify the land use area of different field.

2.3.3 Weibull equation method : Weibull equation R.I = (years + 1)/Rank
I.e. T= (n+1) / M is used to determine the recurrence interval for different magnitude of flood.

3. Result and Discussion

3.1 Socioeconomic Data

3.1.1 Gender of the respondents : In this Study, out of 68 respondent 36 respondent were male and 32 respondent were female comprising 53% male and 47% female, shown in Figure 4.

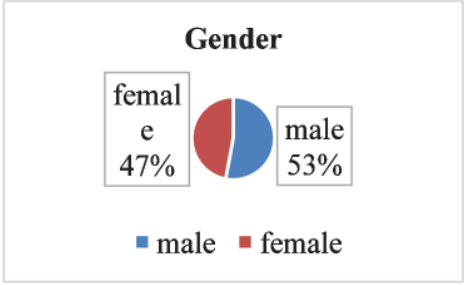

Figure 4: Gender of the respondent

3.1.2 Family Size of the Respondent : The table shows that 25 % of the respondent Have less than or equal to 3 members in their family, 59% respondent have 4 to 5 family member and about 16 respondent have greater than 5 member in their family. This shows that average family size was found 4.5.

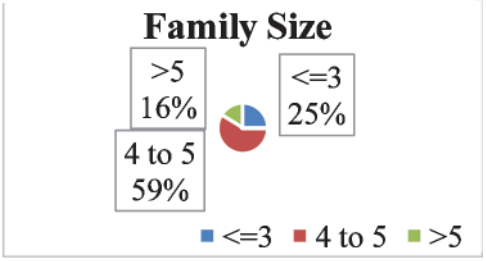

Figure 5: Family Size of the Respondent

3.2 Land Holding : The total area of Thakurbaba Municipality ward no 4 is 1156.88ha. Out of which 3.404 ha. Cover by bush, 931.8309 ha. Land is used for cultivation. The data showed that 28.975 ha. Land covered by forest, 22.30198 ha land covered

by Grassland and remaining part is covered by rivers and its bank, river materials.

3.3 Land cover by Different Year flood : Different Years flood cover different areas of land in different year which causes different impact in that areas like degrade fertility of cultivated land, Damage crops etc. In normal condition the cover of land by flood is directly proportional to stream flow (m3/s) on river.

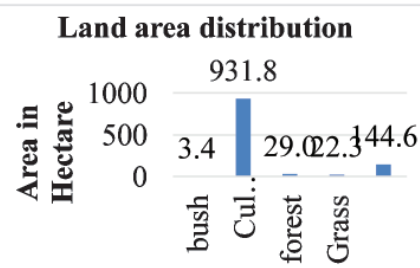

Figure 6: Land area distribution in thakurba-bamun. ward. No 4.

Table 1: Area (ha.) Land cover by Different year flood

Flood Year	Bush	Cultivation land	Grass
2052	0.868995	175.497089	20.437434
2064	1.240231	312.656176	19.946977
2071	1.538144	411.135747	20.162602
2074	0.174994	46.276849	20.088175

3.4 Flood Frequency analysis : The result of different years return period, flood frequency analysis based on maximum instantaneous flow recorded atBabai river from year 1990-2014 using Weibull equation method are summarized in figure 7 below.

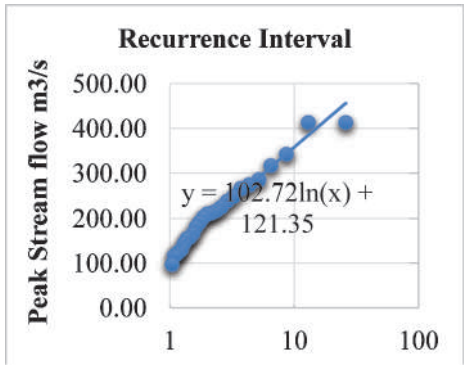

Figure 7: Recurrence interval of Flood

3.5 Flood Vulnerability Analysis : Digitization of flood hazard map over land use map has shown that the cultivated land (cropland) 411.135747 ha in Thakurbaba municipality ward no 4 was the most affected land by 25 years flood.

Similarly, the area affected by the same flood for settlement area is 26.4 ha. And least affected area is forest. In the lower section of Babai river i.e. cropland settlement is seriously affected also settlement will be affected in upper section of Babaiwatershed.In 2071Sediments reached up to 1495 meters towards Mainawar and Bardadha Around 985 meters from river. Some part of the cultivated land is converted in to sandy, barrel land.

Figure 9: flood vulnerability map

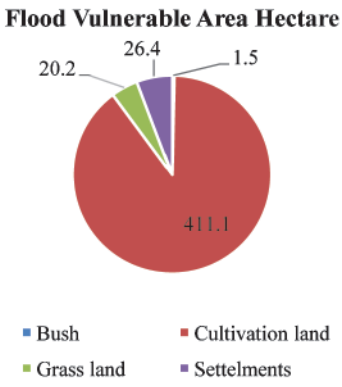

Figure 8: Flood vulnerable Area (ha.)

3.6 Flood and its history : In Thakurbaba municipality the highest record of peak stream flow in babai was recorded 413 m3/s in 2014 august and 2007 July i.e. at monsoon season. This was to much higher than normal year maximum stream flow. There were mainly 4 flood which causes more damages and loss. The data shows that maximum flow in normal year is 285m3/s which is very less than theflooded year. The both data is recorded in monsoon season. The data of different year is presented below. Where FY= Flooded Year and NY= Normal Year

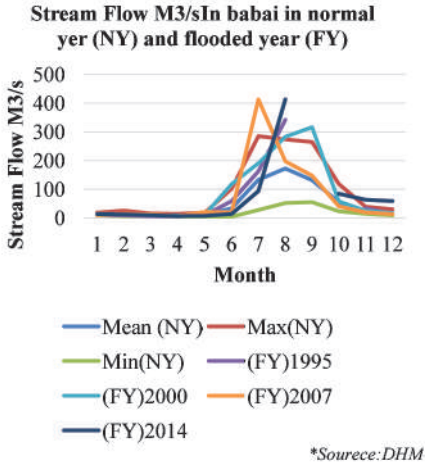

Figure 10: Maximum stream flow recorded in babai

3.7 Yearly Extreme Rainfall : 20 year Extreme rainfall data was collected from department of hydrology and metrology this 25 year data shows that rainfall is the main cause for flood at that reason. Data shows that the extreme rainfall in 2014 is recorded maximum in 15th august 2014.

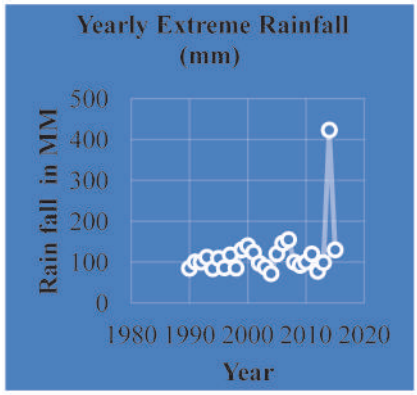

Figure 12: Yearly Extreme Rainfall in MM

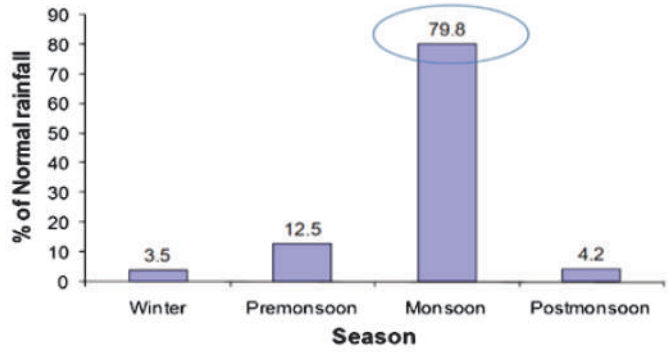

Figure 11: % of rainfall in Different 4 season

3.8 District Emergency operation centre : DEOC is the part of MOHA's which helps on relief in disaster period, give the training about disaster preparedness and develop emergency preparedness and response capacity. It always works to reduce the impact and loss by disaster like events. In different time period DEOC helps on relief in collaboration with different sector and collect the data of sources available, Need and the no of people who are affected by disaster like flood. The DEOC have above Materials for disaster relief, Here is also included the need of materials to make a rescue effective and minimize or reduce the damage and losses by disaster.

Table 2: Materials available on DEOC Bardiya

Year	2071 (No.)	2074(No.)
Beneficiaries (relief)	109962	60560
Redeemer human resources	500 police+206Armed police+ sena 160+	300(police + Armed police 325+sena 83+Red cross 150)
Rescued people	15350(helicopter 350)	12500(Helicopter 327)
Affected H.H	3859 fully+13517 partially	13362 (Fully 2173+ partially 8962)
Affected Population	165000	74327
Fully Affected population	93189 fully	12438
missed	13	0

**Source: DEOC Yearly Report 2074*

Conclusion

The study shows that impact of different floods on property and agriculture. The Flood at starting of monsoon caused low impact on agriculture but at the mid and end of monsoon cause much impact on field crops, there is maximum impact on paddy. Flood not harm only at the time of flood it also cause long term problem up to many years like decrease in productivity. Study also showed that construction of dam helps to minimize impact on settlement and agriculture, this

result may give important information for other flooded area to minimize or mitigate the human loss, property loss and impact on Agriculture. Most of the flood event occurs at monsoon season and the main cause of flood is rainfall so we should aware at monsoon season. DEOC also should fulfill the need of materials by collaboration with government and other agencies. The DEOC planning shows it collect rescue materials for only estimating population of 3500, but the analysis showed that 10000 people may affected by future disaster event at the same time, so that this cause late on relief and may decrease the effectiveness due to lack of materials and manpower. The result obtained from Weibull equation for different return period of flood can help in decision making. The relation between flood discharge and flooded area shows that there is increment of flooded area with increase in discharge. Most of the people tends to forget about the past disaster and start living in Same area so that It is very important to keep the record of the past disaster and make the people always aware of the type of disaster likely to occur in the area and measures to be taken against. It is also important to conceptualize people with the feeling that thought disasters cannot be controlled or stopped completely but its effects can be minimized or mitigated through social and technical endeavors. Thus this study will facilitate for disaster management by providing various information.

Recommendation

Flooding is a natural process and its control is beyond the capability of human efforts. However, the magnitude of flooding and its impact can be reduced to a certain extent through development and effective implementation of land use zoning. The problem of increasing risk and vulnerability are not only associated with physical features, but also with socioeconomic conditions. Programs well integrated with physical processes and socio-economic development is therefore needed. These type of mathematical models are useful in predicting future scenarios. Because of different limitation faced regarding the data, following recommendation are made to improve the accuracy of flood data its impact and effectiveness of DEOC. More accurate data were prepared for making a future plan related to different disasters the training should give for data collector to improve the data quality and to avoid data repetition problem.

Population growth can be extrapolated through statistical method for assessing damage in more realistic manner The need/gap of materials for rescue should be fulfilled on time to reduce impact by flood. Dam on river side helps to minimize flood damage and loss so dam construction is recommended for flood vulnerable area.

Acknowledgment

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Assessment of Air Pollution in Chabahil, Kathmandu Metropolitan City, Nepal: A Community Perspective

Er. Prakash Gyawali

Prof. Narbikram Thapa, PhD

Abstract

The study aims to assess the effects of air pollution in public health and socioeconomic situation in Chabahil, Kathmandu Metropolitan City. Air pollution has become the serious problem in the Kathmandu Metropolitan city. The air pollution has caused serious allergic problems in public health due to dust and carbanmonooxide emission. In the study reveal that the nasal congestions (58 %), sneezing (69 %), cough (75 %), hyperacidity (64 %), eye itching (64 %) etc among the local people in the area. Similarly, non-allergic cases have also been reported due to air pollution. There has been found negative trend of air pollution level as compared to previous one in the study areas due to high carbon gas emission, dust and poor environmental sanitation etc. The overall changes in air pollution level have found significantly difference from 2.83 to 9.16 out of ten. The mean score difference is 6.33 during before and after situation mapping in the study areas. There has been found significant air pollution increased after ten years in the study areas.

Keywords: *Air Pollution, Vehicular emission, Respiratory infections, Inhalable dust, environment, public health*

1. Introduction

1.1 Background

According to the 2011 census survey a total of 51,581 populations reported in Chabahil Ward No. 07 of Kathmandu Metropolitan City (CBS, 2011). There are 30 km of roads in the ward, 40,400 sq. m. of which are black-topped (http://kathmandu.gov.np/sites). The ward neighbors the Buddhist pilgrim destination of Bouddha on one side and the holiest Hindu temple of Pashupatinath on the other. Ancient monuments like Chabahil's Ganesh temple and Charumati Bihar help to give character to the ward. Mitra Park, located in the center of the ward, heightens its attraction. Even though physical infrastructure like roads, drinking water, sewerage and telephone is available in almost all parts of the ward, they are in need of maintenance at present. Also, street lighting needs to be extended. The ward is bordered by Ward Nos. 6 and 8 in the east, Ward Nos. 4, 5 and 33 in the east, Ward Nos. 4 and 6 and Kapan VDC in the north, and Ward Nos. 8 and 9 in the south. The total area of the ward is 153.5 hectares. The road types have been presented below (Table 1).

Table 1: Road Type in Chabahil Area of Kathmandu Metropolitan City

Road Types	Length (km)	Condition %		
		Good	Fair	Poor
Blacktopped	8.61	30	35	35
Gravel	9.63	27	42	31

Dirt	11.28	15	40	45
Track/Trail	5.22	40	35	25
Brick Paved	2.4	60	30	10
Stone Paved	0.07	100		

Source: http://kathmandu.gov.np/sites, 2017

The condition of road seems to be not good quality as international standard due to poor planning, unplanned city, poor governance, poor maintenance etc. as observed. There has found more traffic jam in the areas that increases more time consuming to the travelers. There has found poor environmental sanitation and dust pollution around the study areas that caused acute respiratory infections, chronic obstetric pulmonary diseases (COPD), nasal congestion, eye infection etc. as experienced by the local people.

1.2 Condition of Air Pollution

WHO (2014) stated that the air pollution has become a serious environmental concern and a public health risk in Kathmandu Valley. The concentration of particulate matter less than 10 microns (PM10) in the Valley's ambient air is already several times higher than WHO safer limit and Kathmandu is one of the most polluted cities in Asia with regards to PM10 and PM 2.5 level (WHO, 2014b; CAI-Asia, 2006). However, MOEST (2005) has pointed out that the levels of gaseous pollutants such as oxides of nitrogen, oxides of sulphur, and ozone have not been found to be very high, they may increase in the future with increasing motorization. Furthermore, levels of toxic chemicals such as polyaromatic hydrocarbons (PAH) may also be high due to combustion in brick kilns and diesel vehicles (MOEST, 2005). Yale University (2014) has pointed out that Nepal ranked second last after Bangladesh in terms of air quality and its effect to human health (Yale University, 2014). World Bank (2012) stated that Nepal is the fastest urbanizing country in South Asia and Kathmandu Valley is the fastest growing metropolitan area in the region (World Bank, 2012). According to CBS (2011) the valley has observed rapid urbanization and population growth in last few decades. The annual population growth rate is 4.3 % in the Valley and the annual motorization rate is 12% (CBS, 2011; DoTM, 2014). The Kathmandu valley is especially vulnerable to air pollution due to haphazard urbanization, rapid motorization, valley centric industrialization and its topography.

Brimblecombe (1987) has defined the air pollution as the presence of substances in air at concentrations, durations and frequencies that adversely affect human health, human welfare or the environment. Air pollution is not a recent phenomenon. The remains of early humans demonstrate that they suffered the detrimental effects of smoke in their dwellings (Brimblecombe, 1987). At every level of economic development, ambient air pollution poses a serious challenge that cannot be left to private initiatives, even in established market economies. There are a number of reasons why air pollution problems tend to be ignored in private negotiation and decision making. The damage caused by air pollution is often difficult to perceive, even when the effects are substantial, and people rarely know the levels or sources of the pollution they are being exposed to. Even if they did know, there are no markets through which to negotiate reductions in air pollution (in

economic terms, air pollution is an externality). And even if there were markets for clean air, they would not operate efficiently, since many of the benefits of better air quality are public and cannot be bought and sold on an individual basis (again, in economic terms, clean air is a public good). It is no coincidence that economists often use air pollution examples to help describe the different forms of 'market failure'. Without effective policies, supported by good science, air pollution will tend to be excessive at every level. Especially in low and middle income countries, governments also have difficulty coming to terms with air pollution and health problems. The overall extent of air pollution problems is often poorly understood. The information and policy tools needed to take effective action are often lacking. There are well founded concerns that inappropriate air pollution controls can inhibit economic growth, alongside unfounded concerns that even well designed air pollution policies are anti-growth. The few who might be seriously hurt by air pollution controls are often more vocal and influential than the many that could benefit. In the absence of public pressure, governments too are inclined to ignore air pollution problems. Both public and governmental concerns about air pollution are increasing, however, and significant actions to improve air quality are increasingly evident in middle income countries. It would be inappropriate for low and middle income countries to adopt the air pollution policies of high income countries. It would be equally inappropriate for them to replicate the very slow process of air pollution policy development that occurred historically in high income countries. If the emerging debates about air pollution and health are to lead to effective policies, it is critical that they be locally driven.

1.3 Aim and Objectives

The aim of the research is to assess the effects of air pollution in public health and socioeconomic situation in Chabahil, Kathmandu Metropolitan City.

The following objectives have been set:

To assess the impact of air pollution in public health focusing to Chabahil area of Kathmandu Metropolitan City, Kathmandu District , Nepal.
To analyze the air pollution level and its negative impacts on health and socio-economic status of the local people etc in the study areas.

2 Methodology

The participatory approaches and methods were used during the study. The key informants interview, participants' observation, score ranking, happiness mapping, etc methods were used during the information collection. Mainly, the study has been based on primary and secondary source of information. The descriptive statistic like frequency distribution, per cent was used for the analysis of information.

3 Results and Discussion

3.1 Effects of Air pollution

Spengler and Dockery, (1981) stated that the air pollution reduce the lung capacity in human being. The second mechanism by which these react is obstructive or interfering in nature without

chemical reaction. The thinner particulate deposited in human lung interferes with normal functions and causes lung diseases or non-specific functional changes such as asthma, blood pressure, ENT (eye, nose and throat), fatigue, gastrointestinal diseases, bronchitis or reduction of lung capacities and cancer. If there is a chemical reaction of the material, it may bring about silicosis and pneumoconiosis. If it contains things such as hydrocarbons, etc., it may bring about fatal diseases such as cancer. Particulate by covering the leaves' surfaces and plugging the stomata reduces the absorption of CO2 from the atmosphere, the intensity of sunlight and thus suppresses the photosynthesis and growth of plants. It also reduces visibility by absorption and scattering by solid and liquid droplets. Total exposure to an individual to a specific pollutant is determined by the concentration of contaminant and the duration of its exposure (Spengler and Dockery, 1981). TERI (1995) has argued that the exposure to indoor and outdoor air quality is different because they always change with time and diurnal pattern (TERI, 1995). Anon (1997a.b) pointed out that the health status and the exposure level of a typical population have similarity in terms of habitat, drinking water source, indoor microclimate, domestic fuel consumption, movement pattern, overall living standard, general sense of health and hygiene literacy and interaction with locality and work place (Anon, 1997a, b). Certain airborne particulates such as pollen, fungal spores, house dust mite and animal dander (Tilak 1989) upon inhalation cause certain allergic reaction involving respiratory system such as allergic rhinitis, topic dermises and asthma (Arruda et al. 1992; Fernandes 1995). Secondary photolytic reactions in the atmosphere with organic fractions and oxides of nitrogen and sulfur further has increases the PAH concentration (Schoential, 1964). These are of marked environmental concern due to air pollution as several of them are either known to be carcinogens or are suspected carcinogens and mutagens (Andrews et al. 1978; Hoffman and Winder 1968). Exposure to SPM is also an equally serious risk to health. Inhalable SPM, particularly less than 10 lm in size, can pass through the natural protective mechanism of human respiratory system. The smallest particulate (2 lm or less), which are coming primarily from diesel, pose a much greater risk because of their greater ability to pass through the human respiratory system and cling to inner tissue of the lung. It has been reported that more than 2,000 premature deaths occurred in Quetta in 2004 due to SPM. SPM includes all air-borne particles in the size range of 0.5–100 lm. The actual health damage caused by dust particles depends upon its nature and composition (Binder et al. 1976). The effects of SPM are attributed to mild eye irritation mortality (David 1995). Automobile exhausts and certain industrial pollutants contain NO2, which caused by photochemical reaction produce O3 and affect allergic asthmatics by augmenting allergic responses (Steinberg et al. 1991). Similarly, SO2, NO, particulate matter and acid aerosols affect pulmonary function and cause inflammation of bronchial mucous (Giuseppe et al. 1993; Karen and Michak, 1991). It has been observed from several studies that air pollution plays an important role in the genesis and augmentation of allergic disorder and it is described as a disease of civilized society (Bonai et al. 1994; Dennis 1996). Most of the developed western countries have adopted 25 and 1.5 lg/dL as the safe limits for blood Pb levels in adults and children, respectively (Neelman, 1993). In view of toxicity at all levels, options have been suggested to adopt 10 lg/dL as blood Pb limit for general population (Boeck, 1980). The sources of air pollution in Kathmandu Valley have been presented below (Fig.1). Fig. 1: Source of Air pollution in Kathmandu Valley (http://doenv.gov.np/files/download/Report, 2017).

3.2 Building Structures

In the study areas there have been found different types of building structures that include clay mortar, clay mortar and plaster, cement mortar, RCC frame etc. Many building has not found good condition except RCC frame due to poor quality of construction materials, poor designs and not yet properly repaired and maintenance (Table 2).

Table 2: Building Structure in Chabahil Area of Kathmandu Metropolitan City

Building Structure	Percentage	Condition %		
		Good	Fair	Poor
Clay Mortar	2	40	40	20
Clay Mortar & Plaster	25	50	35	15
Cement Mortar	40	85	15	-
RCC Frame	30	80	20	-
Other	-	-	-	-

Source: http://kathmandu.gov.np/sites, 2017

3.3 Impact of Air Pollution on Public Health

The air pollution has caused serious allergic problems in public health due to dust and carbanmonooxide emission. There have been reported nasal congestions (58 %), sneezing (69 %), cough (75 %), hyperacidity (64 %), eye itching (64 %) etc among the local people. Similarly, non-allergic cases have also been reported due to air pollution as experienced by respondents (Table 3).

Table 3: Estimation of Allergy symptom

Complaints	Total no of cases	Condition	No of persons	Percent
Nasal congestion	12	Allergic Non-Allergic	7 5	58 42
Sneezing	13	Allergic Non-Allergic	9 4	69 31
Cough	12	Allergic Non-Allergic	9 3	75 25
Hyperacidity	11	Allergic Non-Allergic	7 4	64 36
Eye itching	11	Allergic Non-Allergic	7 4	64 36

Source: Focus Group Discussion, January, 2019

3.4 Sources of Principal pollutants in outdoor and indoor pollution

There are many sources for the air pollution which causes the problem in the public health's and environment. There have been identified the predominantly outdoor and indoor sources of pollutants that cause problems in the public health. The air pollution has become the serious public health problems in Kathmandu Valley particularly in the study areas as well. Some of the major sources and pollutants are presented below (Table 4).

Table 4: Principal pollutants and sources of outdoor and indoor pollution

Principal Pollutants	Sources
	Predominantly outdoor
Sulphur dioxide & Particles	Fuel Combustion, Smelters
Ozone	Photochemical reactions
Pollens	Trees, grass, weeds, plants
Lead, Manganese	Automobiles
Lead, Cadmium	Industrial emissions
Volatile organic Compounds, Polycyclic, Aromatic hydrocarbons	Petrochemical solvents, vaporization of unburned fuels
	Both indoor and outdoor
Nitrogen oxides and carbon monoxide	Fuel Burning
Carbon dioxide	Fuel burning, metabolic activity
Particles	Environmental tobacco smoke, resuspension, condensation of vapors and combustion products
Water vapor	Biologic activity, combustion, evaporation
Volatile organic compounds	Volatilization, fuel burning, paint, metabolic action, pesticides, insecticides, fungicides
Spores	Fungi, moulds
	Predominantly indoor
Radon	Soil, building construction materials, water
Formaldehyde	Insulation, furnishing, environmental tobacco smoke
Asbestos	Fire-retardant, insulation
Ammonia	Cleaning products, metabolic activity
Polycyclic aromatic hydrocarbons, arsenic, nicotine, acrolein	Environmental tobacco smoke
Volatile organic compounds	Adhesives, solvents, cooking, cosmetics
Mercury	Fungicides, paints, spills or breakages of mercury containing products
Aerosols	Consumer products, house dust
Allergens	Consumer products, house dust
Viable organisms	Infections

Source: adapted from WHO, 2000b

3.5 Before and Now Situation of Local People about Air pollution

The score ranking tool was used with the participation of community women and men respondents to measure the before and after situation mapping of air pollution level in the study areas. There has been found negative trend of air pollution level as compared to previous one in the study areas due to high carbon gas emission, dust and poor environmental sanitation etc (Table 5). The overall changes in air pollution level have found significantly difference from 2.83 to 9.16 out of ten. The mean score difference is 6.33 during before and after situation mapping in the study areas. There has been found significant air pollution increased after ten years in the study areas due to increased numbers of vehicles, poor environmental sanitation, poor governance, poor monitoring etc.

A total of 10 seeds of bean (assumed to be 100 per cent) were provided to the respondents to measure the changes over the period of ten years as compared to previous one. The focus group discussion was used that included women and men members of local groups in the scoring exercise. Each group members were allowed to participate in the discussion before scoring in the before and now situation mapping. It was noted that higher the score greater the performance during the score ranking by the respondents. The community perception was map out based on the judgment of the respondents. This was measured in relative terms.

Table 5: Perception Mapping of Before and After Situation of Air Pollution in Chabahil Area

Parameters	Before 2009 January	Now 2019 January	Difference	Impact
Acute Respiratory Infection	3	9	6	Increase pneumonia, cough, asthma
Cardiovascular Diseases	2	10	8	Increasing heart problem
Noise pollution	2	10	8	Increasing stress level
Carbon Emission	3	8	5	Nasal congestion, asthma etc
Dust pollution	3	9	6	Cough, nasal congestion
Eye Itching	4	9	5	Eye infection
Mean score	2.83	9.16	6.33	

Source: Focus Group Discussion, January, 2019

3.6 Perception Mapping of Local People about Air Pollution

When asked about the perception towards the air pollution level in the study areas, the respondents have scored 150 (100 %) for unhappy. The study shows that the almost all respondents have found unhappy with the poor quality of air pollution. People are really getting irritating and facing serious problems from the intolerable limit of air pollution due to emission of carbanmonooxide from vehicles, dust pollution and poor environmental sanitation etc. The local people have urged

to government to maintain the air pollution at normal standard level. The happiness mapping tool was used to map out the perceptions of the local people towards air pollution level in the study areas (Table 6).

A total of 10 corn seeds assumed as 100 per cent were given to each respondent. The community perception was mapped out based on their direct observation, experience and best judgment of the respondents. This was measured in relative terms. The frequency represents the scoring of the respondents as simple, easily understood and adaptable parameters at local level.

Table 6: Perception mapping for Air pollution

Parameters	Frequency	Percentage
Very Happy	00	0
Happy	00	0
Unhappy	150	100
Don't Know	00	0
No Response	00	0
Total	**150**	**100**

Source: Local Member of Chabahil Area, January 2019

3.7 Mitigation Measures for Urban Air Pollution

The improvement of the socio environmental conditions and reductions of health burden within Kathmandu, Chabahil city can be argued not only on the public health grounds but also on the basis of long-term economic prosperity of the city. The pollution problem has reached such an alarming level that no soft option would help to salvage the situation. A strong-willed government backed by alert populace can address the problem of increasing air pollution in an effective way (Shukla et al. 1997). A variety of problems need a variety of solutions. But it is equally important to stress upon air quality monitoring as well as the study on the health effects. A model for the assimilation has been made and is given by a first-order dynamic function (McEnvoy, 1990). The empirical model for predicting long term average SPM concentration can be utilized for analyzing the effects of various traffic reduction strategies. To create a strategic plan for air quality management (AQM) program, a consultation with a wide array of interests is required. Epidemiological data from hospitals and other agencies are to be considered as the starting point for identifying linkage between ambient air quality levels and chronic or acute health problems. Some target groups (i.e. traffic constables, roadside hawkers, etc.) and nontarget groups (such as people living in parts of the city where traffic congestion is less or rural people) were selected on a random basis and monitored. This phase of data collection constituted the critical phase in developing a meaningful AQM program. The benefits of reducing air pollution are to be projected. AQM program becomes successful if it includes the assessment to justify the necessary expenditures. There are many influencing tools which are to be used for full compliance of environmental goal, i.e. clean air. Specifying is necessary in selecting the option for mitigating of air pollution. Although the main source of air pollution is the transport sector, industry also plays a key role. For mitigating air pollution in the city of Kathmandu, limiting emissions from both stationary (industry) and mobile (transport) will be required. A future plan is to shift phase wise the medium and low polluting

industries in industrial area outside the city limit. Industries should be encouraged to switch over to cleaner fuels such as natural gas. Energy conservation options are to be encouraged. Industries should be encouraged to develop methods to tap alternative energy source. Internal control regulation should be made obligatory for all industrial sectors. Options for reducing air pollution from mobile sources include replacing old vehicles, maintaining in-use vehicles more effectively, using alternative cleaner fuels, reformulating fuels, improving traffic management, expanding mass transit systems and improving the road capacity (Calvert et al. 1993). Most of the vehicles are diesel driven and SPM concentration was also found to be high. The cost of reformulating diesel oil is high, but it should be high priority to reduce SPM. Liquid petroleum gas (LPG) and compressed natural gas (CNG) should be introduced in a phase manner. Catalytic converters that reduce exhaust emission and emission standards of vehicles should be enforced strictly. Kathmandu grew up so haphazardly that improving the infrastructure is a logistic and economic nightmare. By keeping the main arterial road pothole free, footpaths free from hawkers and widening the roads wherever possible should be given top priority. Improved practices for managing traffic can reduce congestion significantly. An improved plan can include incentives and disincentives such as restricting use of main arteries, encouraging car pooling, providing incentives to use public transport, improving public transit system or establishing new ones, taxing cars entering the city limits, imposing steeper parking fees, and imposing environmental tax on automobiles. Traffic management and road improvements should be given high priority to reduce the air pollution in Kathmandu. In all these proposals, health benefits should be included to prove justification for subsidies. The number of trees per square kilometer was found to be 2 whereas ideally it should be 100. Therefore, immediate steps should be taken to increase the number of trees after proper inventory of all species in Kathmandu. Open spaces and parks (2 square ft per person) should not be encroached upon, and proper eco-designing of these areas should be done immediately.

4 Conclusion

Kathmandu is found to be one of the most polluted cities in Nepal. The study shows that the status of air pollution is found to be critical and has reached threatening level. Air pollution assessment and impact of on human health arising in the area showed high level of imprint score. The premature death due to SPM is reported to be very high and the children are the worst affected groups in Kathmandu. A strategic plan has been proposed and the mitigation measures suggested to control the urban air pollution would improve situation if implemented properly. There is no well-defined guideline for the assessment of the status of urban air pollution and its impact on public health. No systematic studies have been reported to evaluate the status of urban air pollution and its impact in the cities of Nepal and there will be immense implications of the suggested approach and the future application of such assessments is to manage the urban air pollution problem. Urgent action needs to be taken to make the city's air breathable and reduce the negative impact on public health, economy and environment. The air pollution level of Kathmandu Valley has been affected by brick kilns of Bihar and Uttarpradesh of India as well. There is a need of lobbying and advocacy to influence policy and practice in neighboring country also.

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Social Cost Estimation Of Aircraft Landing And Take Off Emission For International Fleet Operating At Tribhuvan International Airport, Kathmandu

KritiNepal[a]*, MukeshDangol[b], SunibabuKhatry[c] and Parbat Raj Thani[d]
[a]*Bird Conservation Nepal, P.O. Box: 12465, Kathmandu Nepal
[b] Ministry of Culture, Tourism and Civil Aviation, Kathmandu, Nepal
[c]Nepal Environmental and Scientific Services, Kathmandu, Nepal
[d] Bird Conservation Nepal

Abstract:

The study was devised to result social cost based on aircraft landing and take-off emission at Tribhuvan international airport for the period of 2012 and 2013. The emission calculation was accomplished by using Tier 2 methodology adopted from 2006 IPCC Guidelines for National Greenhouse Gas Inventories whereas the social cost has been dependent upon the type of aircrafts and number of LTOs. The Tier 2 results entailed that the total yearly LTO emissions for the study period were 37921.91t (LTO: 11451), and 38281.22t (LTO: 11619). CO2 was the dominating emission ranging to over 97.5% of the total emission. The highest cost was attributed for oxides of nitrogen and lowest for carbon monoxide in both studied years. The average yearly social costs for the emitted LTO gases ranged from Npr 366171 to Npr 37042866. The social costs will be a vital option for TIA for enhancing the environment concerns regarding air quality.

Keywords: *Aircraft engine emissions, social costs, landing and takeoff (LTO), TIA (Tribhuvan international airport)*

1. Introduction

The aviation industry plays a major substantial role in global economic activity as it facilitates economic growth by transporting business and leisure passengers along with goods around the world. Being the fastest mode of transportation, aviation promotes globalization by connecting the world (Derudder and Witlox 2008). However, aircraft engines emit pollution into the atmosphere during flight whereas on the ground they generate noise and toxic emissions that affect the environment and quality of life of people living near airports.

Aircraft engine emissions have extensive impact on human health, vegetation, materials, ecosystems and the climate. The impact of aircraft emissions on the chemistry of the atmosphere at altitudes is quite different from the impact of pollution emitted at ground level. At ground level the impact of aircraft emissions is of major importance, since most airports are close to urban areas. Emissions from aircraft create two levels of effects. Firstly, emissions from aircraft landing and taking off and emissions from surface access trips and airport-related vehicles create local air pollution while aircraft emissions during the cruise have a global impact. The US Federal Aviation Administration (FAA) 2005 states that the pollutants emitted from aircraft engines are similar to that of automobiles (Figure 1.1), i.e. sulphur dioxide (SO2), oxides of nitrogen (NOX), carbon monoxide (CO), volatile organic compounds (VOC); unburned hydrocarbons / soot (HC) and water vapor (H2O).

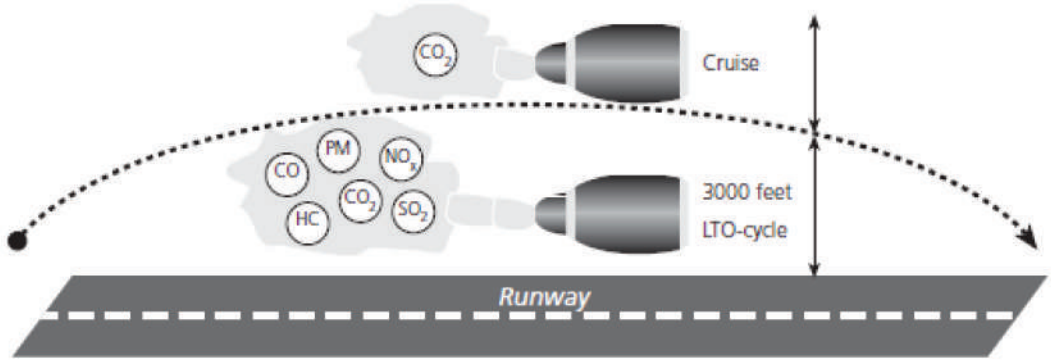


Figure 1: Major Emissions During LTO and Cruise Flight Stages

Source: Climate Change and Aviation (2009)

The LTO emissions are considered as emissions from aircraft engines during taxi, take off, and landing to an altitude of 3000 ft (Hume and Watson 2003; Kesgin 2006).

2. Objectives of the Study

The general objective of the study was based on the quantification of LTO emission and relevant assessment including social cost. The specific objectives of the study were as follows:

To quantify major (CO2, NOX and CO) and minor (CH4, N2O, NMVOCS, SO2, BC, HC, and PM2.5) aircraft engine emissions during landing and takeoff cycle.

To determine the social cost of such emissions for LTO phase of the flight and study the emission charging mechanism for TIA.

3 Methodology

The emission inventory had been accomplished by using IPCC (Chapter 3: Mobile Combustion, 2006 IPCC Guidelines for National Greenhouse Gas Inventories) / ICAO calculation software Tier 2 (ICAO Airport Air Quality Manual 2011). Among the three Tiers adopted by IPCC, Tier 2 has been applied to estimate different species of emissions during the LTO phase of the flight from international fleets. The calculation was based on IPCC Guidelines for National Greenhouse Gas Inventories 2006. The LTO emissions were calculated from total number of LTOs where specific emissions were evaluated by using individual default emission factor as stipulated in IPCC (2006) for CO2, NOX, CO, CH4, N2O, NMVOCS, BC and EEA guideline (2013) for PM2.5. Engine emission social cost was derived through the application of direct valuation method (Pearce and Pearce 2000, Dings etal. 2003, Lu and Morrell 2006) for each pollutant. To use this method, the required air traffic movement data was extracted from Flight Permission Section, Terminal Management Division at Tribhuvan International Airport Civil Aviation Office. Tier 2 method is only applicable for jet fuel use in jet aircraft engines. The emission and social cost estimation is limited to aircraft engine emission only. Moreover, for this study purpose using Tier 2 calculation, the aircraft types cited as others in the flight permission data obtained from TIA were excluded.

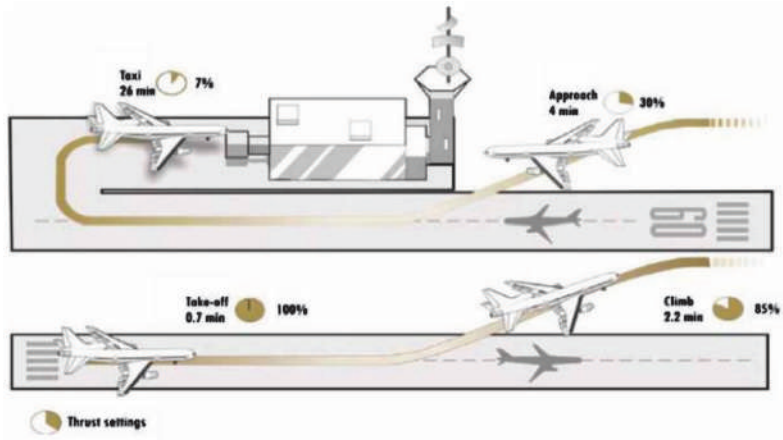
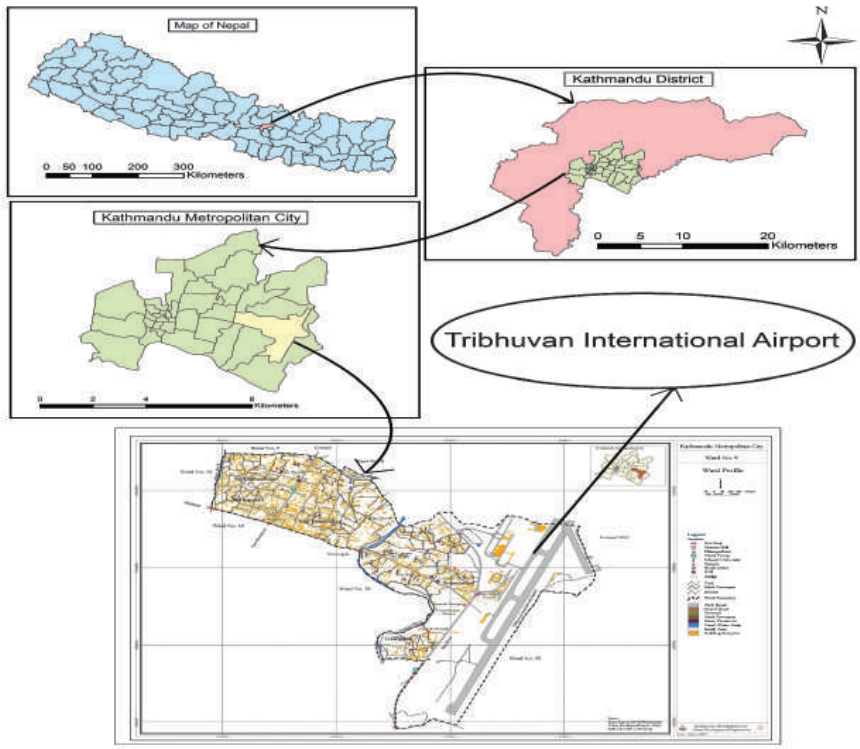


Figure 2 : Landing and Takeoff Cycle (Source: ICAO (2013))



(Prepared using Arc GIS 9.3)

Figure 3: Location Map of TIA

4. Result

Landing Take Off (LTO) Characteristics

A total of thirty one different types of aircrafts (characteristic representation of six different manufacturing companies) landed at TIA during two years of study period. Eight different types

of airbus (A320; A310; A319; A332; A343; A330; A321; A333) and six types of Boeing (B752; B738; B737; B739; B743; B772;) and other miscellaneous aircrafts (DC10; MD82; MD83; B190; ATR45; ATR43, ATR 72) completed LTOs at TIA (Figure 4.2). Airbus (12982 LTOs, 56%) was found to be the dominating manufacturer in Nepalese airspace followed by Boeing (9116 LTOs, 40%), MacDonnell Douglas (495 LTOs), ATR (443 LTOs), Douglas (27LTOs) and Beechcraft (7 LTOs) (Table 4.1).

Table 1 : Manufacturer Wise Annual LTOs

Aircraft Types (Manufactured Basis)	Yearly LTOs		
	2012	**2013**	**Total**
Airbus	6563	6419	**12982**
Boeing	4382	4734	**9116**
Miscellaneous 1(DC/MD)	261	261	**522**
Miscellaneous 2 (B190/ATR)	245	205	**450**
Total	**11451**	**11619**	**23070**

Emission load

The average emission per LTO for carbon dioxide (CO2), oxides of nitrogen (NOx), carbon monoxide (CO), sulphur dioxide (SO2), hydrocarbon (HC), particulate matter (PM2.5), methane (CH4), nitrous oxide (N2O), non-methylated volatile organic carbons (NMVOCs) and black carbon (BC) were calculated to be 3236 t/yr, 15 t/yr, 8 t/yr, 1.02 t/yr, 0.82 t/yr, 0.1 t/yr, 0.08 t/yr, 0.11 t/yr, 0.74 t/yr and 41 t/yr respectively (Figure 4.5). Besides, carbon dioxide, the emission load for BC was found higher (Average: 471.8 t/yr, about 61.4%).

Table 2 : Yearly LTO Emissions Load at TIA, (t/yr)

Pollutants	Emission Load, (t/yr)		
	2012	**2013**	**Average**
CO_2	37156.33 (97.99%)	37509.99 (97.99%)	37333.2
NO_x	170.22 (0.45%)	172.42 (0.45%)	171.3
CO	92.07 (0.24%)	92.19 (0.24%)	92.1
SO_2	11.75 (0.03%)	11.87 (0.03%)	11.8
HC	9.48 (0.02%)	9.46 (0.02%)	9.5
$PM_{2.5}$	1.15 (0.003%)	1.16 (0.003%)	1.2
CH_4	0.96 (0.002%)	0.95 (0.002%)	1.0
N_2O	1.23 (0.003%)	1.26 (0.003%)	1.2
$NMVOC_S$	8.54 (0.02%)	8.52 (0.02%)	8.5
BC	470.17 (1.24%)	473.4 (1.24%)	471.8
Total	**37921.9**	**38281.22**	

LTO vs. Emission

The yearly average of LTOs number was 11535±754.71. But, the yearly average LTO emission of CO2, NOX, CO, SO2, HC, PM2.5, CH4, N2O, NMVOCs and BC for the study period were 37333.16±1588.75t, 171.32±9.85t, 92.13±0.55t, 11.81±0.51t, 9.47±0.10t, 1.15±0.06t, 0.95±0.02t 1.24±0.10t, 8.52±0.09t, 471.78±14.52 respectively. Likewise, the yearly average LTO emission for Airbus regarding to respective parameters were 20065.51±2687.68t, 84.85±5.84t, 53.85±12.06t, 6.34±0.84t, 5.99±1.62t, 0.64±0.09t, 0.61±0.17t, 0.75±0.05t, 5.38±1.46t and 253.70±33.78kg. Similarly, for Boeing they were 16242.62±5744.98t, 82.61±24.00t, 35.87±15.68t, 5.14±1.82t, 2.91±1.63t, 0.45±0.22t, 0.28±0.16t, 0.45±0.22t, 2.63±1.48t and 205.67±72.75kg.

Social Cost Assumption

The social cost was estimated on the basis of emission and LTO basis. The calculated annual average cost for carbon dioxide (CO2), oxides of nitrogen (NOx), carbon monoxide (CO) sulphur dioxide (SO2), hydrocarbon (HC), particulate matter (PM2.5) per LTO were NPR 139831351 (37333.16t), Npr 216033350 (171.32t), NPR 1150269.5 (184.2642t), NPR 10026980 (92.1t), NPR 5321814 (11.8t), NPR 24193911(1.16t). The result entailed that the highest cost was for oxides of nitrogen (54.47%) followed by carbon dioxide (35.26%) and least was for carbon monoxide (0.29%).

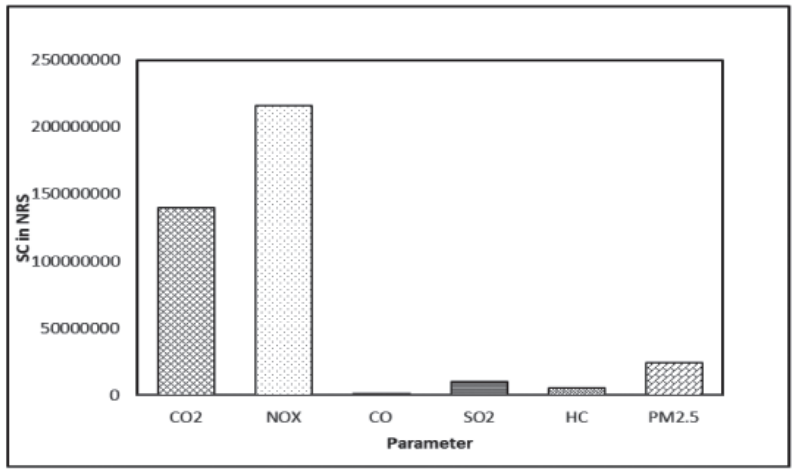


Figure 4: Pollutants wise total social costs

Environmental Cost Version

The environmental cost here is attributed as the engine emissions social costs. The annual average environmental cost per landing (Table 3) at TIA was calculated to be CO2 (Npr 12122.35), NOX (Npr 18728.51), CO (Npr 99.72), SO2 (Npr 869.27), HC (Npr 461.36), PM2.5 (Npr 2097.43). For generalization purpose, the CO2 and other greenhouse species of global relevance have been excluded in the local considerations in TIA.

Emission Cost	CO_2	NO_x	CO	SO_2	HC	$PM_{2.5}$
Average emission cost (NRS/landing)	12122.35	18728.51	99.72	869.27	461.36	2097.43
Annual emission cost (NRS)	279662701.6	432066700	2300538.9	20053960	10643629	48387822

Table 3: Pollutants Wise Emission Cost

5. Discussion

5.1 LTO Emission

The study result showed that CO2 was released in substantial amount, which contributed to over 97.5 % of the total aircraft emissions compared to other gases at LTO phase. The reason behind this is related with the chemistry of turning fuel into propulsive power. Common airliners burning kerosene-type fuels primarily produce carbon dioxide and water (Wahner et al. 1995; Lewis et al. 1999; Anderson et al. 2006; Lee et al. 2010), which is directly related to the burned fuel, with minor variations due to the carbon-hydrogen ratio of the fuel. Therefore, the only way to decrease carbon dioxide emission is to increase fuel efficiency.

5.2 Emission Reduction

The historical analysis of the emission load and social cost provides insights in trend and pattern of emission and provides inputs for emission reduction alternatives and policy formulation regarding charging mechanisms.
Market-based measures that include emissions trading, emission related levies - charges and taxes, and emissions offsetting are among the elements of a comprehensive mitigation strategy to address emissions from international aviation that are being considered by ICAO. Regarding economic instrument, outlying engine emission charges are deployed in some airport like Zurich Airport and Swiss airports, Stockholm and other Swedish airports. However, there are only few airports applying engine emissions mitigation measures and currently only two countries apply engine emissions charges, one is being Switzerland, the other Sweden. Some airports in developed countries have restrictions on the use of aircraft engines, ancillary power units and ground power units.

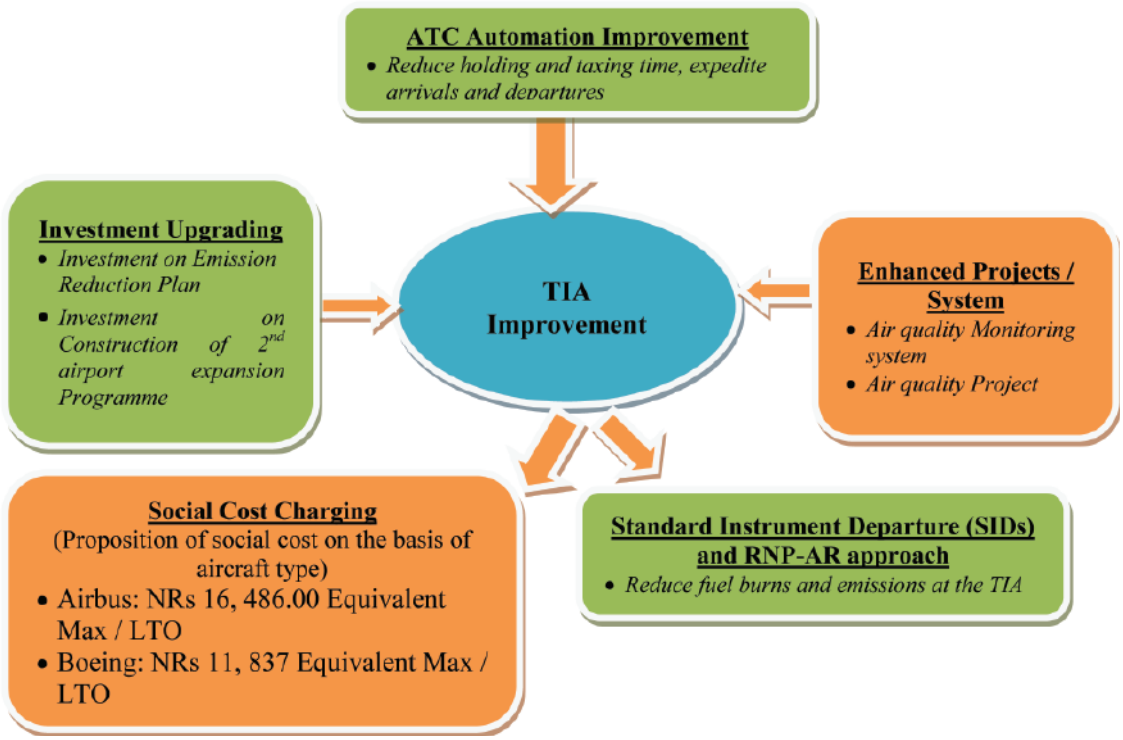
As per CAAN Act, 1998 there have not been any guidelines, regulation or measures regarding environment protection including TIA in Nepal. Besides, there is lacking of environment management section/division/cell in the organizational structure of CAAN to combat environmental issues including aviation related local air quality and aircraft emissions. Nepal's Action plan on CO2 emission reduction (2013) was submitted to ICAO environment branch where CAAN proposed measures on reduction of greenhouse gases emissions from Nepalese Aviation sky where different navigational approaches like L626 RNP route, RNP-AP approach (Qatar airways has been performing the RNP AR at TIA since Oct 1st 2012), Radar Vectoring approaches are projected whereas other measures include renewable fleet andconstruction of new international airport. Besides, economic instruments so far engine emissions charges are not applied for the aircrafts at TIA, which may be one of the mitigation measures for cleaner sky.

5.3 Emission Reduction Measure at TIA

Being ICAO contracting member state, Civil Aviation Authority of Nepal is committed to follow the ICAO guidelines and supports the ICAO mission. Nepal has voluntarily agreed to work under the ICAO mission for the reduction of greenhouse gas emission caused by the aviation industry in Nepal. CAAN is working toward this mission by taking appropriate measures. However, beside these approaches CAAN should also give attention toward emission reduction at LTO phase as well as should incorporate different Air Traffic Management Procedure to reduce emission during land and takeoff since emission reduction measures like Alternative Fuel, Aircraft technologies are not feasible regarding Nepal aviation industry.

5.4 Room for TIA Improvement

Besides showing the degree of emission and its environmental cost several applications of this result and methodology can be applied at TIA. First of all, aircraft emission social costs can be used to determine the Emission charge levels. Furthermore, these costs can form the input of cost-benefit analysis of an airport or an airport system because an airport is operating most efficiently when its marginal social benefit is equal to its marginal environmental cost. Any movement beyond this threshold would result in more environmental damage than its generated benefit to the society. The same applies to an airport system. Given the residences and booming human population in and around the vicinity of TIA, the emission impact and its social cost would be higher in magnitude as compared to the estimation in this study. However, complete analysis of these applications is beyond the scope of this paper and requires further research. Several factors should be included for the environmental improvement at TIA.



Conclusion

The international flights operating at TIA showed increasing trend. Airbus was dominating airspace followed by Boeing at TIA. The carbon dioxide load in the total emission was found very high (about 97.99%) whereas there were least emission contributions of major GHGs (methane and nitrous oxide) and fine particulates in total loads The highest social cost was for oxides for nitrogen followed by carbon dioxide and least was for carbon monoxide. QTR, THA, NAC, JAI and AIC were top most airlines that has highest cost for emission. The increment of LTO resulted increase of the ATF consumption and emissions. Moreover, as the emission increases cost also increases. Aircraft emission social cost can be used to determine the emission charges level as charges will provide incentives for good environmental practice at TIA as well as these cost can serve as input for cost-benefit analysis. The social costs charging system has to be determined either on carbon charging (CO2) or pollution prevention modalities (NOx or PM2.5). However, in order to set charges on the basis of social cost, various critical assumptions should have to be taken into consideration.

Acknowledgement

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Municipal Solid Waste Management in Godawari Municipality of Lalitpur District, Nepal

Bima Maharjan
Central Department of Environmental Science, TU
Correspondence Author: bima.mhrz@gmail.com

Abstract

The study was conducted to analyze the solid waste management practices in Godawari Municipality. Householdsurvey was carried out to collect the data followed by commercial and institutional survey, key informant interview and observation. The study reflects that the average household waste generation was found to be 0.7 kg/day and the per capita waste generation was found to be 0.14 kg/capita/day.The total household waste was found to be 4.03 ton/day. Similarly, the average institutional waste and commercial waste were found to be 2.21 kg/capita/day and 4.98 kg/day respectively. NEPCO Nepal collect the wastes from household in door to door collection manner.Only 36.2% of surveyed households practice segregation at source before disposal. The 59.1% household has composting facilities. Since municipality has no landfill site for proper waste management, people haphazardly dumped the solid wastes. The 47% household burned the wastes whereas 27% dumped the wastes into the open places such as road/drain, river streamand barren land. Thus, an appropriate policy and strategies with technical guidelines should be developed for effective SWM to guide locals in municipality.

Keywords: *Composting, Municipal waste, Resource recovery and Waste management*

Introduction

There was hardly any problem of solid waste management in Nepal in the past. The wastes were locally managed in all the areas and almost all the wastes were organic in nature and were used as a manure. But these traditional practices could not continue due to increasing trend in urbanization and industrialization which has become the main cause of increased generations of solid wastes (Luitel, KP, 2009). Therefore, municipal solid waste management is one of the major environmental problems (Pokharel and Viraraghavan, 2005)facing by municipalities of Nepal (Practical Action Nepal, 2005). It involves activities associated with generation, storage, collection, transfer and transport, processing and disposal of solid wastes. But, in most cities, the municipal solid waste management (MSWM) system comprises only four activities, i.e., waste generation, collection, transportation, and disposal. The wastes collected were dumped on nearby river banks or in open fields. This has created lack of proper solid waste management. Poor solid waste management may result in urban, sanitary and environmental problems. As a consequence, concern has been raised on adverse health effects particularly among those living in the areas where solid waste is inappropriately dumped. Thus, this study concentrates on describing the current waste situation and the current MSW management practices in Godawari Municipality of Nepal.

Materials and Methods

Study Area

The study area is the Godawari Municipality which is located in Lalitpur District, approximately 10 km South-East of Kathmandu, situated on the foot of Phulchowki Hill (largest peak in Kathmandu Valley) in the Bagmati Zone of Central Nepal. The geographical position of Municipality is within 27°36'05.71" N and 85°21'55.07" E with an altitudinal range of 1361-2099 m above sea level (Google earth, 2016).The climate is subtropical to warm temperate with three seasons round the year: cold and dry winter (October to February), pre-monsoon dry summer (March to May) and monsoon (June to September) (Gaire, 2015). In December, 2014, Nepal government created Godawari Municipality by combining five Village Development Committees: Godawari, Badikhel, Bisankhunarayan, Godamchaur and Thaiba. Per 2011 National Population and Housing Census, the population of five VDCs will make the total population of 28,793 (Male – 14168, Female - 14625) for Godawari Municipality and the total number of households is 6739 (CBS, 2011). Population density of Godawari Municipality is 15 per hectare.

Methods of Data Collection

Transect walk

The transect walk was done to gather the information about the Godawari Municipality. Household SWM survey. The household survey was conducted from 21 May, 2016 and was done with the help of semi-structured questionnaire to know the socio-economic status, waste management, their knowledge, attitude and practices. Sample size for the household survey was calculated by using the equation proposed by Salant, 1994 and Rea, 1997 which was shown below.

$$n = \frac{tp2 * p * (1-p) * N}{tp2 * p * (1-p) + (N-1) * y2}$$

Where,
N=Total population size
n= Total sample size
y= Sampling error
tp= Sampling probability

The total 94 households were found from the equation at 95 % confidence level and at 10 % sampling error. And the interviews were conducted in each sampled ward. The random sampling was done for the survey in wards of municipality. The sampling was done in six wards out of twelve wards which includes 2 urbans (ward no. 10 and 12), 2 semi-urban (ward no. 5 and 8) and 2 rural (ward 1 and 3) areas. The wards are divided into their background (urban, semi-urban and rural) by consultation with municipality staffs and field visits. The number of populations, urban houses, commercial sectors and industrial development are the key components for division of areas and the selected areas for sampling represent not only the urban, semi-urban and rural areas but also represents all the 5 VDCs developed before creation of Godawari Municipality.

Institutional and industrial survey

Six educational institutes, 4 ward offices, 1 NGO and 1 financial institution, 6 shops and 6 hotels were surveyed. Similarly, the five industries three textile, 1 bakery, 1 picklefactory were also surveyed.

Commercial waste survey

Six shops and six hotels were surveyed. For the hotel survey, the manager or owner of hotels were concerned to get the information on the total waste generated by their hotels which consist one 3- Star hotel, 3 restaurants, 2 guest house and 1 home stay. There is only one hospital located in municipality. So, the nurse of hospital was consulted for the information on medical waste generation. Similarly, one primary health care center, 2 health posts and 2 medical halls were visited and consulted the resource person and got the required information.

Key Informant Interview

The key informant interview was carried out using semi-structured questionnaires with key informants representing municipal officials and non-government organizations, local organizations teachers, hoteliers.

Observation

Observation in the field was done to records the feature of everyday life of local people and about the situation and context in which they are living. Similarly, photographs were taken during household survey.

Secondary sources of data

The information regarding the municipality was taken through the compilation of five VDC profile. Similarly, reports, journals, articles were reviewed for the general information of municipality. Various internet websites were surfed to get required information of this study.

Data analysis and interpretation

The collected data were processed in the Statistical Package for Social Science (SPSS 16.0 version) software and Microsoft Excel in order to calculate necessary indices and the results were presented in the different diagrammatic form.

Result and discussion

The average household waste was found to be 0.7 kg/day. The average household size was found to be 5. The survey indicated that the average waste generated from each house was found higher within the range of 0.5 to 1 kg per day. The average waste generation is shown in the figure1 below.

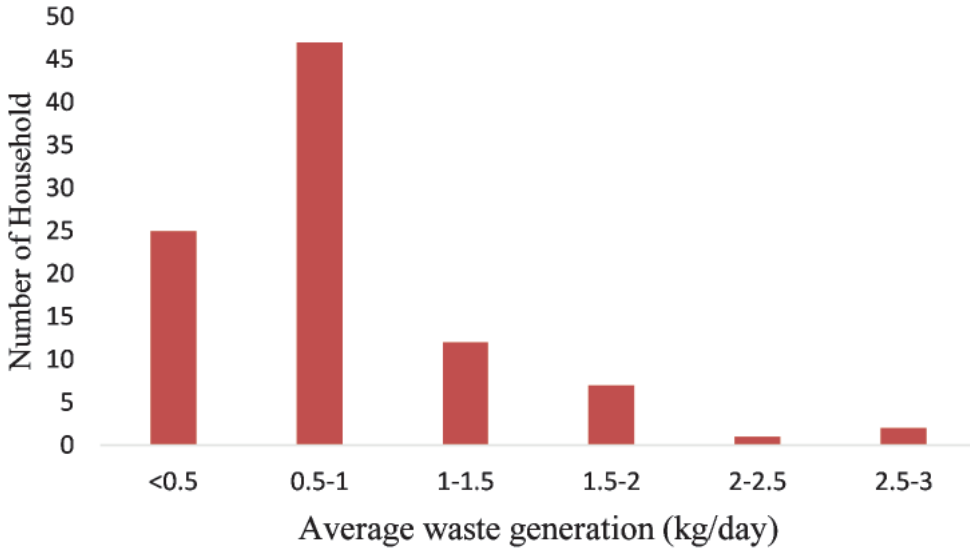

Figure 1.AverageWaste Generated from Each Household

The per capita waste generation was calculated by dividing the total waste produced by the number of people living in that household on that day. Thus, the per capita waste generation was found to be 0.14 kg/capita/day. This is a bit lower than the average waste generation rate in Nepalese municipalities, which are 0.25 kg/person/day. The total population of Godawari Municipality is 28,793, thus, the total amount of household waste generated in the municipality comes out to be approximately 4.03tons/day. Study revealed that the households from core urban areas gave higher waste generation rates i.e. 0.875 kg/day. Per capita waste generation in urban, semi-urban and rural areas is shown in figure 2 below.

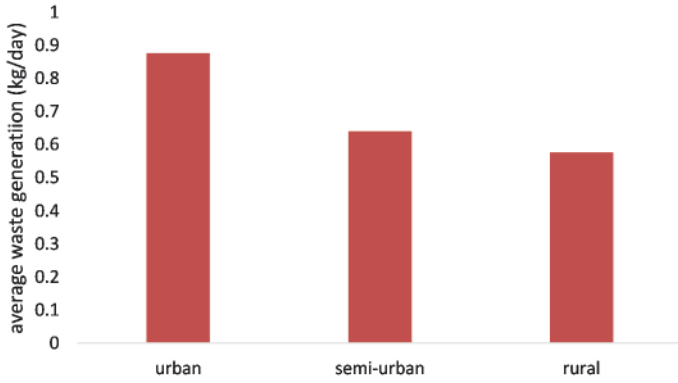

Figure 2.Area-wise Household Waste Generation

Study revealed that the major composition of household wastes consists of biodegradable wastes, plastic, paper, glass, metals, textiles, rubber and woods. The survey indicates that the highest waste fraction is organic which is similar to the study by ADB, 2013.

The average per capita waste generation from sampled institutions was found to by 2.214 kg/day. The total number of registered institutional settlements of Godawari Municipality was 163. The total amount of institutional waste generated in the municipality was found to be 0.34 tons

per day. the composition of waste generated from each institutional settlement showed that the institutional wastes consists higher amount of organic wastes followed by paper. Similarly,the average commercial solid waste generation within municipality found to be 4.981 kg/day and the total commercial wastes generated in the municipality were found to be 0.65 ton/day. The composition of waste from commercial sector showed higher organic wastes.

Existing solid waste management system

Segregation and collection

From the household survey, it was found that only 36.2 % of surveyed households in the municipalities practice segregation of wastes at source before disposal which is also lower than the study by Duwal, 2015 at Bhaktapur Municipality i.e. 57.5%. They segregate biodegradable wastes either for composition or feeding cattle. Through interaction, it was also found that some of the people gave their food wastes to their neighbor as a fodder for cattle.

Godawari Municipality did not take any responsibility for waste collection process. However, the waste was collected and managed by an NGO named Nepal Environment Pollution Control Organization (NEPCO) Nepal. The NEPCO Nepal collects the solid wastes from around 180 households, institutions, commercial sectors and hospital. It collects the service charge from these sectors depending upon the amount of waste generate and collect the wastes fromm household in door to door collection manner. The survey showed that out of 94 household only 3% household give the wastes to the NEPCO. The wastes are collected from the houses near the black-topped road of urban areas. NEPCO is collecting the wastes in ward 6, 10, 11 and 12 of municipality. There is no any waste collection facility in rural areas of municipality.

Primary transportation and transfer station

The vehicles of NEPCO Nepal come twice a week to collect the wastes in the morning time to collect waste from the road, market place and street corners. Among the sampled household which give their waste to the NEPCO, the entire respondent claimed that the tractor is not coming on time and they are not satisfied with the service provided by NEPCO Nepal. NEPCO Nepal has a resource recovery center in Harisiddhi-28 of LSMC. They take a 20 ropani land in lease for 15 years for proper solid waste management. The collected wastes are dumped in one place. Since it collects the mixed wastes, the staffs appointed for segregation segregate the wastes into biodegradable and non-biodegradable wastes.

Final transportation and disposal methods

Among the total wastes collected by the NEPCO Nepal, about 70 % wastes are used for composting, about 15 % wastes are recycled and the rest 15 % wastes are goes to the landfill site for final disposal. The tipper is used for the final disposal of wastes. Tipper carries the wastes from Harisiddhi and brings the wastes to Okharpauwa Landfill Site (OLS), Nuwakot for the disposal once a week.

From the household survey, it was found that the 47 % household burned the wastes. Similarly,

27 % dumped the wastes into the open places; throw into road/drain, near temple areas and barren land. Through the survey it was found that there is a misconception among the local people about the solid waste management. Since they burned all the wastes generated from their household so they thought there is no problem of wastes in their localities. They are totally unaware about the harmful effects of plastic burnings to the health of humans and the environment. The figure 3 below shows the non-degradable waste management practices of people of municipality.

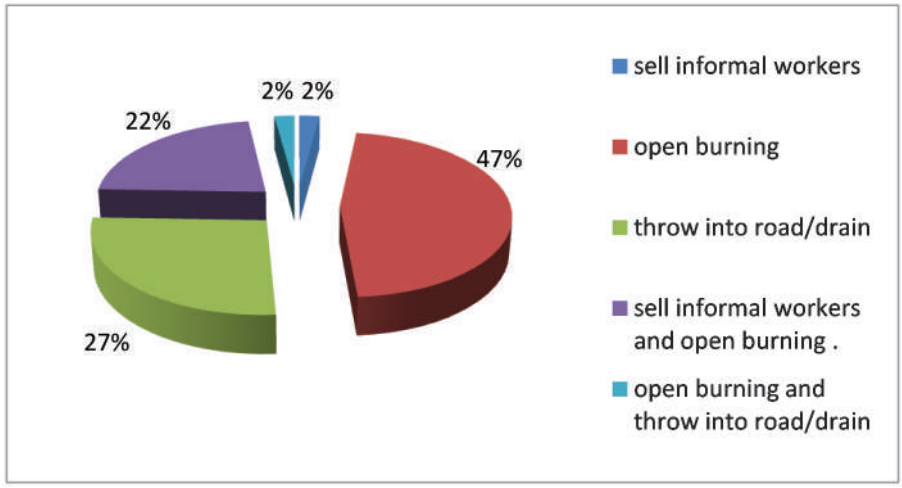

Figure 3. Non-degradable Waste Management Practices

Through the public consultation, it was found that the system of charging by NEPCO is unreasonable and unsystematic. The hotel owner, locals and the schools are interested to give their wastes to NEPCO and are willing to pay for the services if the level of services and is improved and the charge of the service is reasonable.

Resource recovery

Reuse/recycling

Among the sampled household, 24 % household said that they give the wastes such as metals (can beer, iron, brass etc.), glass (beer bottles, hard-drink bottles), paper, cardboards, egg crate, jute sacks, sacks and plastic and rubber shoes to the kabbadi(informal waste collector) people. They collect these waste items whenever generate and stored. Then, they sell it to the kabbadi whenever they visit to their localities. The visits of kabbadi people are not regular. The industries also sell the wastes such as paper, cardboards, textiles and metals to the scrap dealer. Due to lack of proper place for storage of such recyclable materials, the local people used to throw these items in open places. The informal waste picker also collects the wastes from some places mostly the picnic spots and the market areas of municipality. The informal waste collector was consulted during survey and found that they collected almost all the wastes which have recycled values from these places.Local people living in municipality have a traditional knowledge to make theSukul. a type of mat which is popular among the Newar culture in Nepal mostly in ward no. 10, 11 and 12. In making of Sukul, women use the plastics which is one of the best practices of plastic reuse.

Though the local people of Godawari Municipality are practicing the reuse and recycling but they are not well aware about the 3R' concepts (reduce, reuse and recycling).

Composting

Municipality does not have any composting or recycling programs of its own but NGO involved in waste management are practicing composting and recycling.NEPCO Nepal has a composting facility at its resource recovery material center. About 25 % wastes are composted by NEPCO. The compost fertilizers are then sold to buyers.

Study revealed that 59.1 % household has composting facilities and practices composting while 40.9 household do not have composting facilities. The local people use their traditional knowledge for composting. The local people used the traditional knowledge to make the compost. In Newar community, locally the pit is named as 'Saga' and the compost fertilizer is named as 'Sa'.There is no any composting plant operating in the community of municipality.

Special waste management

Godawari Municipality has 1 hospital with 3 beds, 1 primary health care center with 3 beds, 4 health posts and 10 private medical halls. Through the survey, it was found that the hospital segregates the wastes into its compositions i.e. general, infectious and sharp wastes. Then, the hospital wastes are given to the NEPCO for safe disposal without sterilization. The hospital does not have any sterilization equipment such as incinerator or autoclave. The primary health care center burns sharp needles and others after sterilization from autoclave. The other general wastes are also burned into their backyard. The placenta, bloods are dumped into their backyard and they cover it with soil. The health posts burn the generated medical wastes without any sterilization. The wastes from medical halls are also burned without any safe measures. Dead animals are buried or dumped. The burying is done near riverbanks, in barren land and at dump sites. Thus, the municipality should take proper action in order to control haphazard dumping of infectious waste from various medical sectors which was also stated by Tuladhar, 2004 in his study in Lalitpur Metropolitan City.

Public awareness and community mobilization

The organizations such as NEPCO Nepal, NagarikSachetana Kendra, Nepal Red Cross Society, Lalitpur, Thaiba youth Circle, Ganesh MahilaSamuha Cooperative, VindhyoGuthi are engaged in awareness raising program on SWM and cleanliness at their locality.

Conclusion

The study reflects overall waste generation and waste composition and SWM practices in Godawari Municipality The organic waste fraction makes a relatively large contribution to the total weight and it consists mostly out of food remains, kitchen waste.People have lack of knowledge on proper solid waste management. They are practicing waste burning and are unaware about the harmful effects of waste burning in the environment. Municipality lacks technical officer for the sustainable management of MSW. The proper awareness program and effective training on solid waste management is lacking which generate higher fraction of waste. It also seems

lack of coordination and cooperation among the stakeholders and local people for solid waste management. The current practice of dumping waste in open space should be stopped and the waste should be reuse and recycled to the possible extent.

Recommendation

- Waste should be segregated into biodegradable and non-biodegradable waste before disposal at home.
- Waste burning should be stopped andit was recommended to aware them about harmful effects of such activities in the health and environment and about recycling of waste materials and benefits from such recyclable materials.
- Composting should be promoted. Furthermore, in urban areas people have no such place in their backyard for composting. So, in such case, vermin-composting and bin composting is the better option for composting method which can be done even in the small place at home.
- People have good knowledge to make the goods from the discarded waste materials. So, municipality can play a significant role in initiating awareness building programs, technical and methodological advice and assist in creating market mechanisms.
- Coordination and collaborative ownership of stakeholders on SWM should be built up.

Acknowledgement

I am grateful to Solid Waste Management Technical Support Center for providing me this opportunity to conduct this study and also thankful to the local people of Godawari Municipality for providing valuable information and sharing their knowledge on waste management.

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Provisioning Ecosystem Services: Potential of Payment for Ecosystem Services (Pes) In Taltalaiya Wetland Area, Sunsari

Arjun subedi

Abstract

In this context of PES study was conducted on Taltalaiya wetland area of Sunsari, Nepal with the aim of assessment of payment for provisioning ecosystem services. A random sample was conducted in 60 households adjoining to the Taltalaiya wetland area in November 2017. Household questionnaire survey and Key Informant Interview, direct observation, etc were the methods adopted to gather the data, to identify the buyers and sellers of services and factor affecting willingness to pay. The result shows that Taltalaiya wetland area delivers 6 major provisioning ecosystem services that are water for irrigation, water for others purpose (domestic & livestock's), fish farming, fodder, food and Medicine. 2 Community Forest User Groups and Taltalaiya conservation committee is the service provider of the ecosystem services. KII concluded that 200 households in ward no. 2 and 150 households of ward no.3 are the buyers of the provisioning ecosystem services. This research shows that 55% of the respondent accepts the willingness to pay (WTP) while 45% rejects WTP. Out of 8 independent variable set for multiple regression models, 2 variables namely occupation of the people and distance from the lake is the significant variable that affects WTP. The multiple regression result concludes that, the WTP of farmer is 1.220 units greater than other occupational group and with increase in distance from the lake, WTP decreases by 0.427 units.

Keywords: *Payment of Eco-System Service, Willingness to pay*

Introduction

Nepal is the South Asian country being rich in the water resources and wetlands, ecosystem services and its payment can greatly uplift the livelihood of people (Khanal et al., 2014). Wetland refers to the continual water bodies that arise from underground sources of water or by rain. About 6% of total global land comprise wetland ecosystem however, about 5 % (743756 ha) of Nepal's land is considered as wetland (DOAD, 2012). Wetlands are argued to deserve a high priority for conservation because of its most threatened condition than any other natural ecosystem (Shrestha, 2015). Ecosystem services are the benefits or good obtained from ecosystem to maintain human well-beingthat provides various services like provisioning, regulating, supporting and cultural Services (MEA, 2005). Provisioning ecosystem services are all the tangible products from the ecosystem including food, fresh water, fiber, fuel, genetic resources, biochemical, natural medicines, pharmaceuticals and ornamental resources (MEA, 2005).PES involves mechanism in which there is the linkage between buyer and seller in response to payment or rewards by people those who benefits from ecosystem services to those who play a central role in providing or maintaining these services (Lee & Mahanty, 2009). The study of PES implementation in Sardu watershed estimated that the value of ecosystem services like for drinking water, recreational services and support service to be more than NRs. 60 million a year (Khanal & Paudel, 2012).

PES is the important mechanism which helps to proper pricing of natural resources like wetland, river, stream etc, which gives fresh water for us (Khanal, 2012). Nepal is the resource-rich country in term of ecosystem services but government of Nepal neglects the importance of PES due to lack of sufficient research data on PES. Taltaliya wetland area provides wide range of Ecosystem Services to its neighboring urban population, however growing population rate and optimum utilization of the available natural resources tend to degrade the state of the wetland rarea. This study was conducted on Taltalaiya wetland area of Sunsari, Nepal with the aim of assessment of payment for provisioning ecosystem services; to identify the factor affecting willingness to pay for provisioning ecosystem services.

Methodology

Study Area

The study was conducted in the Taltalaiya wetland area of Itahari, Nepal. Taltalaiya wetland is the natural lake covering 49.5 hectares of forest area and its geographical coordinates are 26° 42' 01.46"N (latitude), 87° 18' 00.05" E (longitudes) with elevation of 447 ft. Char Kose Jhadi is the adjoining area of wetland.The study area comprises some parts of ward no. 2 and 3 of Itahari Sub-Metropolitan city. The wetland is at 5 km away from Mahendra highway.

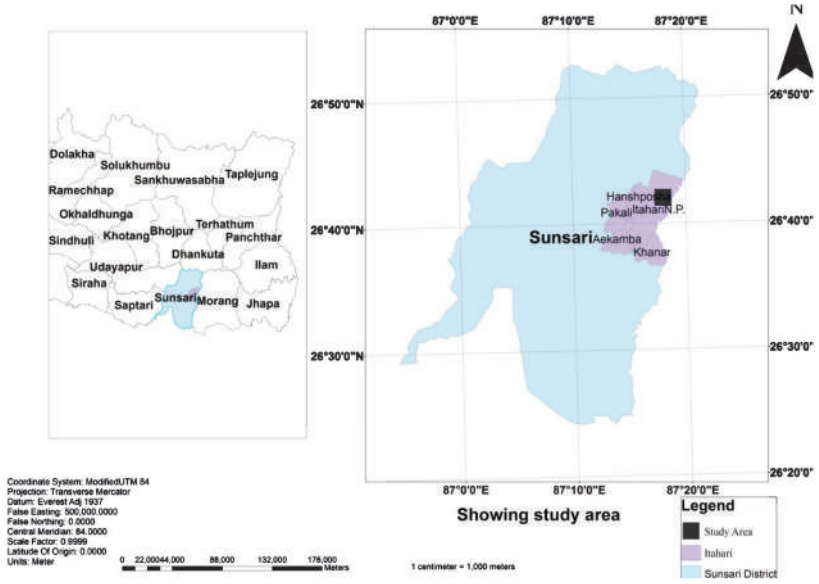

Figure 1: Map showing study area

Data collection

Direct field observation was done to identify Provisioning Ecosystem Services provided by wetland area and to know the beneficiaries of the related area. A questionnaire was developed to collect data about the Provisioning Ecosystem services delivered by Taltalaiya wetland area and to know the factors affecting WTP for provisioning services. Based on this criteria of selecting key informants was identified and interviews taken. A series of open-ended questions posed to

individuals selected. An interview was being qualitative, in-depth, and semi-structured. 8 key informants representing the two-community forest user group, Taltalaiya conservation committee and social group. On-Site observation was conducted in an opportunistic basis. Group of villagers or a single farmer was accompanied to observe the farming area, irrigation services in land.

Data Analysis

Quantitative and Qualitative techniques were used for data analysis. Quantitative data was analyzed from SPSS method in which multiple regression models will be used to determine the existence of correlation between socio-economic factors and WTP for ES. Freidman test was being done to analyze the rank of ecosystem services (ES) through people perception. Qualitative data taken from Household Survey, Key Informant Interview were analyzed by simple statistical tools.

Result and Discussion

Different types of Ecosystem Services were found to be derived from the Taltalaiya area. Result show that about 83.3% of the respondents were familiar with the ES but remaining 16.7% of the respondents were unfamiliar with the Ecosystem services. Ranking using freidman test indicates that most of the respondents agree that water for irrigation is the most important ES they receive from the Taltalaiya wetland area with the mean rank of 1.63 with followed by water for other purpose (domestic, livestock, drinking), fish farming, fodder, food and medicinal use with the mean rank of 2.27, 3.05, 4.37, 4.87 and 4.82. The mean rank 1.63 shows irrigation is the highest priority of available water source. Most of the respondents prioritize irrigation water as top most provisioning services. 3 irrigation canals discharging from this wetland, supports huge number of farmers whose major source of income is from agricultural farming. Irrigation service irrigates 48 bigha of agricultural land and supports 170 households. Tentative out of 200 household in the ward no. 2, 40% of the households benefited from irrigation services and 5% of the households benefits from fish farming and remaining households benefits from other resources. Out of 932 household in the ward no.3, approximately 150 households got direct benefit from the provisioning ecosystem services. Approximately 60% of the households benefits from irrigation services and remaining households benefits from other resources. Taltalaiya conservation committee, Sarswotinagar Community forest users group, Shantinager Community forest users group service provider of these Ecosystem Services.

5 likert scale option 1-not interested, 2-slightly satisfied, 3-moderately satisfied, 4-very satisfied and 5-extremely satisfied was set for this study. Result showed that 45% of the respondents were not interested for willingness to pay (WTP) for provisioning services followed by 5%, 6.7%, 36.7% and 6.7% were slightly satisfied, moderately satisfied, very satisfied and extremely satisfied for WTP. According to Mitchell et al., (1989) the statistical model is,

WTP = (-1.220) Occupation + (-.427) D.F.L+ 6.092

The adjusted R2 change is .615, which showed that the result meet 61.5% of the data on the regression line. The table shows only the results of multiple regressions for WTP. The occupation was significant ($P<0.05$) with negative regression coefficient ($t=-1.220$), suggesting the WTP of the farmer increased by 1.2 units compared to self-employed & others.

Table 1: Results of Multiple Regression Representation

Independent Variable	Willingness to Pay
Constant	.000(6.092)
Gender	.588(-.165)
Occupation	.000*(-1.220)
Age	.777(-.059)
Education	.346(.130)
Distance from the lake	.027*(-.427)
Land holding	.403(.152)
Household income	.866(.032)

Source: Authors own calculation;

** indicates significance at the 5% levels; the parenthesis shows the t-value. Adjusted R2 change =0.615*

Another significant independent variable is distance from the lake with P-value of .027 which is less than .05(at 5% level of significance). So, the distance from the lake is significant variable with negative regression coefficient. The willingness to pay decreases by 0.427 units with increase in distance from the lake. The farmer wants pay for irrigation services although they are far from the lake but other occupational related household were not willing to contribute for WTP.

Ecosystem services and their importance

The resources provided by wetland greatly affect the livelihood of local people. The ecosystem services are found to support a significant proportion of the surrounding of Taltalaiya wetland households. There are more than 2000 households living in the nearby Taltalaiya wetland area.

The present study shows that Taltalaiya wetland is suitable place to provide provisioning ecosystem services. Decade ago the canal was constructed to manage the wetland overflow water for irrigation support to nearby agricultural land. Now day fish farming is also created in wetland and nearby area, which managed the livelihood of nearby huge number of people. In the research about provisioning services and its valuation in Beeshajari lake, (Tamang, 2017) identified four types of provisioning services with important prioritization of firewood and fodder but study on provisioning services of Taltalaiya, the services become different. Most of the people prioritized water for irrigation and fish farming as a top most services in the study area. According to MEA, 2005 the highly prioritize provisioning ecosystem services was fresh water for drinking water.

Willingness to pay for Ecosystem Services (WTP)

The study also explained the factor affecting willingness to pay for provisioning ecosystem services (ES). The significant factors are occupation of the respondent and distance from the lake which affect WTP by respondent. Majority respondents (55%) of the service buyers have shown their WTP; if they are assured to get ES in the Taltalaiya wetland. 45% of the respondents rejected WTP for provisioning services those who were far from those services. Residents from nearby wetland area were not interested for financial contribution for ecosystem services but were willing to contribute volunteer physical labour for conservation of wetland and also for social mobilization support. The PES scheme in Shardu watershed, Dharan showed that about 42%

of the downstream people have accepted the willingness to pay in monetary contribution while remaining 47% people have agreed to give their physical work if necessary (Khanal & Paudel, 2012).

Shrestha, 2015 conducted study in Begnas lake showed that, distance from the lake, occupation status and education of the people are the factor which affect WTP for ecosystem service. Farmer is less willing to pay than businessman. This research finds that occupation and distance from the lake affect WTP for provisioning services in which farmer more are willing to pay than people from other occupation.

Conclusion

The study area emphasizes on the key provisioning services received from the study area and the willingness to pay for the conservation of wetland. The major provisioning services delivered by Taltalaiya to local people was found to be water for irrigation, water for household purpose, fish farming, fodder, food and medicinal plant. Among the provisioning services most of the respondent ranked irrigation water followed by fish farming as top ecosystem services. Two community forest user group & Taltalaiya conservation committee is responsible for seller of such provisioning services. And 350 households in the ward no.2 &3 of Itahari Metropolitan city is service buyer of provisioning services.

Occupation and distance from the lake directly affect the WTP for the proper conservation of wetland area resources. Farmer was more interested to pay than other related occupational group for continuing utilization of irrigation water and fodder. Households within 100 meter zone were more attracted towards WTP. With increase in distance WTP was decreased. Residents beyond 1km did not prefer WTP.

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Climate Change Adaptation Practices of Farmers in Banke District of Nepal.

[1]Jeevan Lamichhane, [2]Surya Adhikari, [3]Tara Sharma,
[1]Regional Agricultural Research Station, Khajura, Banke
[2] SocioEconomics and Agricultural Research Policy Division, Kathmandu
[3]Department of Agriculture, Kathmandu
Corresponding author: jeevanlamichhane7@gmail.com

Abstract

A study was done in 2017 in Banke to document the adaptation strategies of farmers against climate change. Qualitative study was done using both primary and secondary data sources. The key informant survey was mainly used for collecting information from the respondents. Total rainfall in Banke district ranged from 937 mm to 2149 mm in a year, with average rainfall of 1317 mm from the year of 1950 to 2016. Average monsoon rainfall in Banke district was 1127 mm during 1995 to 2016. Trend of maximum temperature of Banke district revealed 0.033°C annual increase for the month of June and 0.044°C in July and August and 0.058°C in September. Farmers with their long term experiences have adapted against the climate change. Farmers have started cultivation of stress tolerant varieties (drought and submergence). Farmers in Banke have also started Direct seeded Rice practice, mulching practice, adopt insurance scheme, zero tillage practice, diversify from the main crop, adopt solar irrigation system, shift the cropping calendar.

Keywords: *Climate change, Adaptation, Farm*

Introduction

Climate change is persistent and irreversible. Mostly the developed nations are affectedby the climate change. The share of Nepal in climate change is very low (Tiwari,et al., 2014). Temperature of Nepalhas risen by 1.70 C in past 30 years (1975 to 2005), and the average temperature increased as 0.060C per year and in particular, 0.040C per year in plain area and 0.080C per year in Himalayas (Shrestha et al., 1999). Nepal has been experiencing considerable changes inprecipitation patterns as well, which has direct impact on overall agricultural productivity (NAPA, 2010). On the other hand, only 26.5% of cultivable agricultural land in Nepal is irrigated, of which less than 50% land has access to water supply all year round (MoAD, 2010). In Nepal, 80 percent of the total precipitation occurs in themonsoon season starting from June and ending in September (Malla, 2009).As a result, agricultural production depends on favorable weather conditions, mainly in the monsoon time. The impact of climate change on water resources within Lesser Himalaya and glacier retreat in the Higher Himalaya of Nepal has been identified (Basyal and Dhakal, 2015). However, there is a lack of published researchon the impacts of climate change on farming systems and the adaptation practices in the southernregion of Nepal, the Terai. The study in eastern Terai by Regmi,2007 has shown that farmers faced arain deficit in the years 2005 and 2006 because of an early monsoon, and crop production was reducedby 12.5% nationwide. Midwestern Terai also faced heavy rain with floods, which reduced productionby 30% in these years (Regmi,2007).

Some review studies carried out by individuals and organizations inNepal and elsewhere have reported that climate change offers both challenges and opportunitiesto farmers, depending upon the geographical regions and types of effects it has produced (SPCR,2010). The winter drought assessment confirmed that production of themajor winter crops, wheat and barley, decreased nationally in 2009 by 14.5% and 17.3%, respectively, compared to previous years (FAO, 2008).

Adaptation is increasingly seen as an inevitable answer to the challenges posed by climate change (IPCC, 2001).There are two main branches of adaptation commonly cited in the literature: autonomous and strategic (Bates et al. 2008; NCVST 2009; Smit et al. 2000). Autonomous adaptation refers to the actions of individuals taken at the household level to make changes that reduce vulnerability to a changing climate, regardless of planning, policies and strategies implemented at the national level. For instance, agricultural households can apply different management techniques that involve less water use, greater cropping intensity, crop diversification, micro-irrigation and small-scale storage, or anything that improves the resilience of the income base during fluctuating conditions. In many cases, without some national level strategic planning, those autonomous adaptation options mentioned above are not possible. For instance, in many cases, income diversification is inherently dependent on infrastructure that can only be provided from the top down. Thus, although autonomous adaptation involves automatic actions taken at the household level in response to changing conditions, the variety of options for those actions is in many cases entirely dependent on national level strategic planning. Strategic adaptation refers to planning, policies or strategies at the national level that proactively responds to the potential effects of CC. This includes direct construction of infrastructure, capacity building, disaster relief planning or a host of different methods that increase national resilience to the potential impacts of CC on both ecosystems and human populations.

Methodology

This research was conducted using a qualitative for collection of relevant data from both primary and secondary sources. As secondary sources of information, qualitative information about the adaptation measures used by the community to cope with the effects of climate change were collected through participatory rural appraisal tools and techniques such as key informants' interviews, focus group discussions, and direct observations during field survey.Key Informants' Interviews were conducted with selected individuals who were considered knowledgeable about the issues of climate change and its impacts on the agriculture production system in the community in general and adaptation practices of the farmers in the study district in particular. The responses and views expressed by the key informants were analyzed and used in cross checking the findings of the study.

Moreover, the information collected through action research carried out with limited participant farmers for two crop seasons was also used for triangulation of the information collected from secondary and primary sources.

Results and Discussions

Climate of Banke

Banke district is one of the mid-western terai districts of Nepal. In 2004, in the month of May, Banke experienced 48°C, which was the highest temperature of the recorded history in Nepal so far. Total rainfall in Banke district ranged from 937 mm to 2149 mm in a year, with average rainfall of 1317 mm from the year of 1950 to 2016(Shrestha and Baral,2017). Though, Ministry of Enivornment (2010) has placed Banke district under very less vulnerable district to climate change, extreme temperatures , less and shifting rainfall pattern and existence of rain fed agriculture (70% out of total arable land) (DADO Banke, 2017) may result into significant decline in agricultural productivity. Average monsoon rainfall in Banke district was 1127 mm during 1995 to 2016. Year 2002 was the year with the least rainfall record of 820 mm and in 2007 there was a big flood in the Banke due to heavy monsoon downpour. Monsoon rainfall accounted for at least 80 percent annual rainfall in Banke district; sometimes it reached 90 percent as well. Shrestha et al. (1999) predicted 0.014°C annual increase in the maximum temperature during monsoon months in Terai region, this analysis of Banke district revealed 0.033°C annual increase for the month of June and 0.044°C in July and August and 0.058°C in September. In this regards farmers have adapted following adaptation practices in Banke district of Nepal.

1) Adoption of stress tolerant varieties :

i) Drought tolerant varieties:

Most of the time there is a delay onset of monsoon in most part of the district. A large part of the cultivated area lies as a dry region in the district. Most of the varieities adapted the farmers do not perform well in drought condititon. Farmers are now introduced with drought tolerant varieties in these areas. The sukhavarieitis like sukhadhan -1, sukha dhan-2 , sukhadhan-3, Radha-4 are widely cultivated in the area. These varieities can withstand drought for 20-25 day. These are the varieties developed by Nepal Agricultural Research Council. These varieties are being popular in the drought area of the distrcict. Across these varieties, the average yield advantage of drought-tolerant varieties over drought-susceptible ones is 0.8-1.2 tons per hectare under drought (IRRI,2018).

ii) Submergence tolerant varieties:

In contrast to the drought condition, some considerable part of the district are submerged prone. Submergence can affect rice crops at any stage of growth, either short-term (flash floods) or long-term (stagnant flooding). The chances of survival are extremely low when completely submerged during the crop's vegetative stage.There is a problem of submergence some parts of the district. During flooding, the rice plant elongates its leaves and stems to escape submergence. Deepwater rice varieties are able to do this rapidly enough to survive. High-yielding modern varieties cannot elongate enough. If floods last for more than a few days, the rice plants expend so much energy trying unsuccessfully to escape that they are unable to recover because of which farmers in the area are unable to harvest as their expectation. So to escape from the loss under circumstances farmers have started cultivating flood submergence varieties like swarna sub-1, Cehrang sub-1, Samba mansuli sub-1.These varieties confers resistance to submergence of up to 14 days. These varieties constitutes submergence tolerant genes sub-1. These varieties have shown a yield

advantage of 1–3 tons per ha following flooding for 10–15 days.

2. Direct Seeded Rice (DSR): DSR is feasible in area having facility of pre-monsoon irrigationwhen needed for proper germination of seed and development of seeding before monsoon or monsoon is delayed by weeks. Dry DSR is a technique where the seeds are directly sown manually or with a machine with no supply of water at the initial stage. Wet DSR is a technique in which seeds are sown in the puddled field. In both the case water requirement for the nursery preparation is not needed. In both dry and wet DSR cost incurred is significantly less than manual transplanted rice. DSR reduce cost of production by 22%. Dry DSR reduced the labor cost approximately by 44%. This can really address the labor shortage.as DSR reduce the intensive tillage especially during puddling of field. Considering the total operational time of tractor, this can simply reduce GHG emission by 14.3%. Direct seeded rice is being popular in Banke district and being widely disseminated. At present commercial farmers are practicing the DSR in the district. Uniform germination and timely weed management are major challenges for success of DSR both pre-emergence and post emergence herbicide application in time is must for proper weed management.

3. Mulching: Mulching is the process or practice of covering the soil/ground to make more favorable conditions for plant growth, development and efficient crop production. Mulching is much practiced in vegetable farming. Lack of irrigation water and decreased frequency of rainfall in dry season has limited vegetable farming in dry season. It was further exacerbated by increasing ascendancy of weeds and insects in vegetable. Few of the farmers are different kinds of plastic film is being practiced as a mulch material in vegetable farming. Since plastic films are costly, there is a wider practice of organic mulch as a mulching material for conservation of moisture for longer duration.

4. Crop diversification: The erratic climatic variation has affected regular crop cultivation in the study area. Crop diversification is often promoted as a strategy to achieve climate resilience. Crop diversification refers to the addition of new crops or cropping systems to agricultural production on a farm. By diversifying, farmers increase the range of potential food and income sources available to them. In many drought-prone areas crop diversification serves as an important climate risk management strategy. Similarly, several farmers have chosen alternative crop instead of rice, wheat and maize. Similarly, some farmers started cultivating perennial fruits like banana which are less sensitive to climate change. The farmers of the rice-wheat belt started to diversify agriculture by including short duration crops such as potato, soybean, bean, cowpea, pea, mustard and maize into different combinations. To compensate lost yield or avoid the risk of single crop, mixed or intercropping were used in the locality. Some farmers diversified their livelihood options in fruits and vegetable farming instead of cultivating cereal crop only.

5. Zero tillage operation : Zero tillage referred as no tillage in which the crop is planted in unprepared soil by opening a narrow slot, trench or band only of sufficient width and depth to obtund proper seed coverage. The weeds are controlled only by chemical means.This operation also reduces the water requirement thus reduces the cost of irrigation.

Results done in the study area showed that very few farmers have started practicing Zero tillage operation in wheat. This may be also due to the fact excessive tillage destroy the structure of the soil and it also incur heavy cost to the farmer which forces them to adopt the moisture conserving practice from zero tillage operation.

6. Insurance : Due to the extreme weather condition like heavy rainfall, hailstorm, storms, strong wind, infestation of diseases and insects caused by the changing climatic scenario farmers are facing huge loss. Agriculture insurance is most common forms of risk transfer in agriculture. Government of Nepal (GoN) has been implementing crop and livestock insurance since January 2013 by formulating crop and livestock insurance directives 2013. Under this directive, government has been providing 75% subsidy in premium to be paid by farmers. Government of Nepal (GoN) has initiated agricultural programs linking with agriculture insurance so that they will continue to insure in the absence of any support program. Suchprograms included youth focused program, spring rice promotion program and othergrant/subsidy programs under different mega projects (eg. PACT, HVAP, RISMFP etc). Most of farmers who were participated in government grant program have limited understanding of crop insurance so that they have discontinued insurance after the end of grant/subsidy program. But if they feel enterprises are risky, realized the importance of agriculture insurance and can get higher returns from the enterprises, they were willing to participate in agriculture insurance. Most of the farmers in the study area do not have adequate information and knowledge about the insurance scheme. Few of the farmers have started insurance of livestock. Some of the commercialized farmers have started the insurance of the crops. Insuring crop and livestock has been slowly emerging.

7. Shift in the cropping calendar: Delayed calendar, changed crop rotation and pattern was also reported by Regmi (2010). Farmers in the study area are themselves being adapted with the changing climate without understanding of climate change and its impact. They are adjusting their farming practices with the experiences they felt long ago and now. Since most of the farmers were with limited resources, it was difficult for them to invest to adopt with the changing climate scenario.Change in planting time such as delay planting in the year of delayed monsoon or early planting in the year of early monsoon were the practices of the farmers. Planting of wheat was delayed by one month due to the late onset of monsoon. Some of the farmers were found to plant wheat earlier to avoid higher temperature during flowering period.

8. Solar irrigation, Drip irrigation : For irrigation in vegetable cropsfew of the farmerswere using drip irrigation using the plastic drum with polythene pipes. Some of the farmers have started using solar system as a source of electricity for running the microirrigation system.For planting rice, some farmers are also irrigating their field through polythene pipe directly connected to the pump sets.

Conclusions

Adaptation to climate change includes all adjustments in behavior or economic structure that reduces the vulnerability of society to changes in the climate system. Farmers have been using their knowledge and experience in implementing adaptation measures at local level. Farmers have adopted both strategic and autonomous adaptations. So, it is important to plan sustainable

adaptation strategies based on scientific research and make farmers prepared to cope with the increasing impacts of climate change in coming days.

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Potential of Methane Gas Emission from Household Waste of Kathmandu, Nepal

Shishila Baniya[1], Om Bam Malla[1,2], Shreejan Ram Shrestha[3]
[1] Department of Environmental Science, Amrit Campus, Tribhuvan University
[2] School of Environment Management and Sciences (SchEMS), Pokhara University

Abstract

Solid waste management has become a major global challenge. Common practice of landfilling or dumping organic waste is not a sustainable waste management practice; it causes loss of potential sources of renewable energy. Researches have shown, anaerobic digestion (A.D) process can utilize organic waste and to produced renewable energy i.e. methane (CH_4) gas. This paper estimates the maximum theoretical CH_4 gas potential from household organic solid waste at Lazimpat, Kathmandu. A total 88 household waste samples were analyzed which shows 82.82% of the total waste by weight as organic solid waste and maximum methane generation potential of 0.75 m^3/kg/day, equivalent to 7kWh electricity. If all the organic waste of the area got processed via A.D process then the area has the potential to generated 276.13 m^3/kg methane gas, equivalent to 2.76mWh electricity in a year. Furthermore, the co-digestion of organic waste can be done to enhance the methane gas production.

Keywords: *Anaerobic digestion, electricity, empirical formula, energy, recovery*

Introduction

Municipalities are struggling to manage the increasing volume of the wastes (APO, 2004; Neupane andNeupane, 2013; Ntesa and Hauptfleisch, 2014; Shrestha and Singh, 2011; Shrestha et al., 2014). Household waste is a major contributor to municipal wastes municipal waste (MSW) with high proportion of organic wastes (ADB, 2013). Anaerobic digestion (A.D) process has been successfully used in stabilizing the municipal organic waste (Leven et al., 2007; Liu and Yuan, 2008). It is a microbiological degradation of organic materials in the absence of oxygen (Oliveira and Doelle, 2015; Rayn et al., 2013). All biodegradable organic waste generated in house including food waste, grass, paper are suitable substrate for A.D process. The degradation process take place in four phases (see table 1) and in each individuals phase is guided by different species of microorganisms (Horváth et al., 2016). Methane (CH_4) is an intended byproduct of A.D which can be collected and combusted for heating, cooking purpose (Abbasi et al., 2012). In one hand this process support to energy recoverywhile in other hand control air pollution. Theoretical methane gas potential study helps to estimate the maximum methane gas production

Table 1. Bacterial genera involve at the different stage of AD

Stage of A.D	Genera involve	Reference
Hydrolysis	*Cellulomonas,Thermomonospora, Acetovibrio , Streptomyces*	(Li and Zhu, 2011)
Acidogenesis	*Acetobactrium, Saccharomyces*	(Li et al., 2011)

Acetogenessis	*syntraphobacterwolinii, clostridium species, lactobacillus*	(Verma, 2002)
Methanogenesis	*methane bacterium, methano bacillus, methane corous and methanosarcira*	(Nalo et al., 2014)

Table 2. Factor affecting anaerobic digestion

1	pH	pH range for the methane production is 6.5-7.5 where the production is high at 6.8-7.6.	(Liu and Yuan, 2008)
		High or low pH range decrease cause decline in CH_4 gas production.	(Nayono, 2009; Zhang et al., 2007)
2	Temperature	Operating temperature of mesophilic digesters and thermophilic digesters are 35°C - 40°C and 50°C - 55°C	(De Baere andMattheeuws, 2012)
3	Substrate characteristics	The degradability and biogas production potential is effected by the wastes components: lipids, proteins, carbohydrates.	(Hartmann, 2003) .
4	carbon/nitrogen (C/N) ratio	The optimum carbon nitrogen ratio is 20:1 to 30:1	(Balat andBalat, 2009)
		High or low C/N ratio cause the decline in production as well as poor performance of reactor	(Adekunle andOkolie, 2015; Khalid et al., 2011; Muzenda, 2014)
		To maintain C/N level of the digester ,waste can be co digested with nutrient rich organic wastes (low C/N ratio) like animal manure or food waste.	(Nayono, 2009)

Material and Methods

Study area

Ward No. 2 of Kathmandu municipality is named after the Lazimpat Area (see figure 1). It lies in northern sector with 3.5 km distance from Kathmandu metropolitan city (KMC) office.

Table 3 General description of study area

Total of number household	3,559
Total number of population	13,448
Building structure	cement mortar and RCC frame
Sewers system	surface drains sewers
Famous heritage	Sakuna Nil Saraswati temple, DayaswarMahadev (Bungal)
Actor involved in solid waste management	private sector, community and ward office

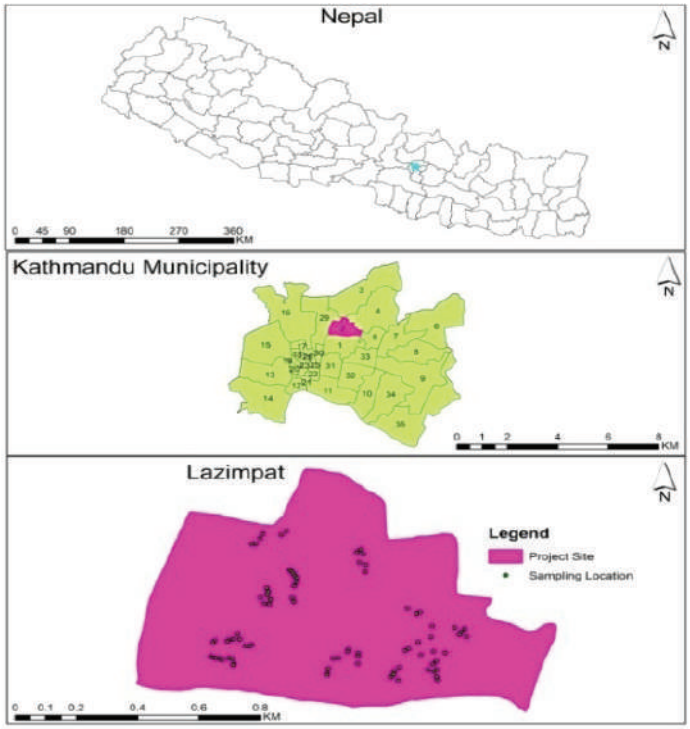

Figure 1 Mapping of Lazimpat Kathmandu

Methods

Data were collected through field survey and Garmin Etrex GPS was used to record of the geographical location of sample household.

Sampling Method

Random sampling method was used to collect the data from the field where the sample size was calculate statically by using the formula

$$n = \frac{Z^2 P * Q}{(M.E)^2\,(R.R)} * \frac{1}{(H.H\,)}$$

Where, n = required sample size, M.E. = margin of error (i.e. difference between sample mean and population (0.055), Z = desired degree of precision we choose 1.96 (n>30). RR= response rate (95%).

Since, we do not know any information about the population, the maximum value of 'p' and 'q' would be suggested to 0.5. The obtained sample size was divided by the average household size (3.78) which was calculated by dividing the total population by household number.

Therefore 88 household was the required sample size to make the study representative. Total 88 household samples were taken in 8 days by dividing the study area into the 4 plot. For the

calculation of the moisture content 4 sample were taken from the each plot. All together 16 sample were analyzed.

Field Data Analysis Method

The moisture content (MC)
10% of the sample taken was place into oven at 105 degree Celsius for two hours. Then the sample were cooled and reweighted. Weighing was done using the digital weighing machine.

$$MC = \frac{initial\ wt - final\ wt}{initial} X\ 100$$

Dry weight (Dwt) = Wet weight (Wwt) - (Wet weight * Moisture content

Calculations

Table 4 Organic waster composition of study area

Component	Wwt	Wwt	Dwt	MC	Composition					
	(g)	(Kg)	(Kg)	%	C	H	O	N	S	Ash
Food Waste	34485	34.48	5.7	83.59	2.72	0.36	2.13	0.15	0.02	0.28
Paper	3073.4	3.073	2.5	20.14	1.07	0.15	1.08	0.01	0.005	0.15
Cardboard	109.53	0.11	0.1	0.21	0.05	0.01	0.05	.0003	0002	0.01
Textiles	92.64	0.093	0.1	0.45	0.05	0.01	0.03	0.00	0.00	0.00
Yard Wastes	504.22	0.504	0.5	0.52	0.24	0.03	0.19	0.02	0.00	0.02
TOTAL	38264.4	38.26	8.8		4.12	0.55	3.48	0.18	0.03	0.46

Where, g= gram, kg=kilogram, C=carbon, H= Hydrogen, O= oxygen, N= nitrogen and S=sulfur
Composition of element = Dry weight of element * Percent by Weight (Dry Basis) of element
For the percentage by dry weight (dry weight) value (Alter and Kaiser, 1974) was used as reference.
Total moisture content H_2O= total Wet weight –Total dry weight
= 38.3-8.8 = 29.4
Moisture content in Hydrogen (H) = (total moisture content /atomic mass of water)* 2
= (29.4/18)*2= 3.27
Moisture content in Oxygen (O) = (total moisture content /atomic mass of water)* 16
= (29.4/18)*16= 26.13

Table 5 Moralized and normalized value of elements

Elements	Without MC	With MC	MC	Atomic Weight	Molar weight Without MC	Molar weight With MC	Normalized mole ratio with MC	Normalized mole ratio Without MC
C	4.12	4.12	-	12.01	0.34304746	0.34304746	366.718	366.718
H	0.55	3.82	3.27	1.01	0.54455446	3.78217822	582.129	4043.149
O	3.48	29.61	26.13	16	0.2175	1.850625	232.508	1978.318
N	0.18	0.18	-	14.01	0.01284797	0.01284797	13.734	13.734
S	0.03	0.03	-	32.07	0.00093545	0.00093545	1.000	1.000

Molar weight of the element = element weight in wastes / atomic weight of element
For normalized molar ratio each element was divided by the least weighted element i.e Sulfur. From the table no.5 waste empirical formula $C_aH_bO_cN_dS_e$ give $C_{367}H_{582}O_{233}N_{14}S$ Where a, b, c, d and e represent proportion of Carbon, hydrogen, oxygen, nitrogen and sulfur chemical respectively in organic waste composition.

Theoretical methane gas potential (with sulfur emission)

Theoretical methane gas $=\left[\frac{\left(\frac{a}{2}+\frac{b}{8}-\frac{c}{4}-\frac{3d}{8}-\frac{e}{4}\right)*22400}{12a+b+16c+14d+32e}\right]$(Raposo et al., 2011)

$$=\frac{\left(\frac{367}{2}+\frac{582}{8}-\frac{233}{4}-\frac{3*14}{8}-\frac{1}{4}\right)*22400}{12*367+582+16*233+14*14+32*1}$$

= 482.219 liter/kg
= 0.000482219 m^3/kg [1 liter =10^{-6} m^3,where m^3 =cubic meter]
Total CH_4 production per day = total organic waste* total organic waste produce per day
= 0.000482219 *1568.83958
= 0.75652 m^3/kg/day
Electricity production potential =0.75652* 10 = 7.56 khw [1 m^3/kg CH^4=10khw(Kilo watt hour)]
Total CH_4 production per year = total organic waste* total organic waste produce per year
= 0.000482219 * 572626.4467
=276.1313525 m^3/kg/year

Electricity production potential= 2.76 mwh [mwh= mega watt hour]

Result and Discussion

Waste composition of Lazimpat, Kathmandu

Total solid waste generation in the area was found to be 1.94 tones with 144.24 gram per capita waste generation value. However, population (Ranabhat, 2015), economic growth (Safar et al., 2016), community living standard and urbanization (Dangi, et al., 2009) are considerable factor influencing waste generation quantity. The percentage value organic food waste was in consistence with KMC household waste but plastic waste (12.0%) and textile (0.9%) (Dangi et al., 2011)

and no hazardous waste and glass was observed from sample site. Variation in production is also subjected to the ecological region (ADB, 2013) and household wastes don't possess consistence characteristics(Salami andSusu, 2011).Report from ADB 2012 Shows that organic waste 64.4, plastic 15.9% paper 8.6% and textile 3.4 (ADB, 2013).

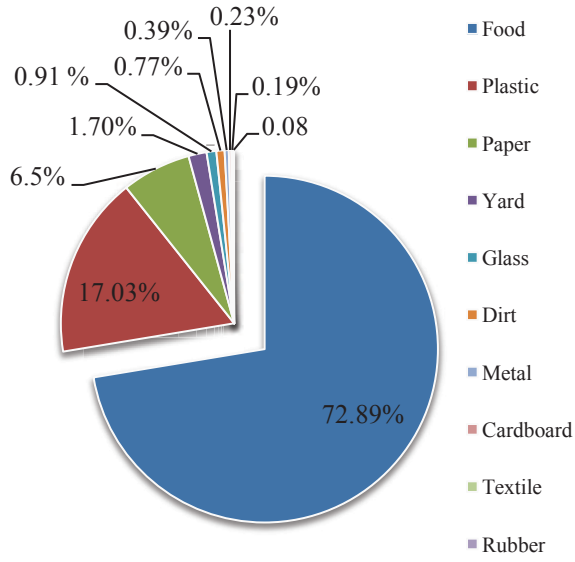

Figure 2 Waste composition of Lazimpat
Inorganic and organic waste Composition

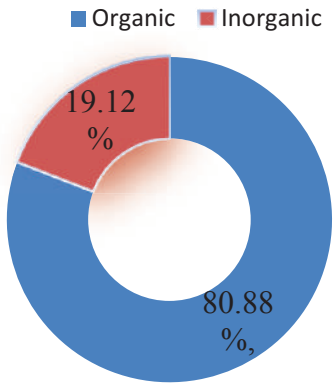

Figure 4 Organic and inorganic waste percentage

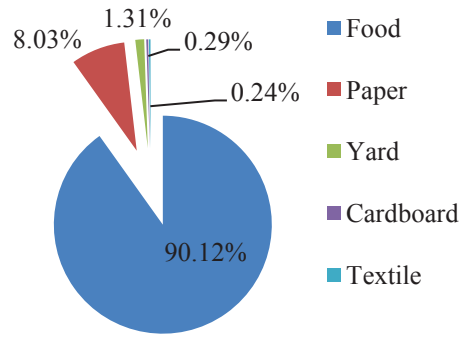

Figure 3 Composition of organic wastes

The per capita organic waste generation in study area was found to be 116.7 gram/day with the total generation value of 1.57 tons/day. This value was higher in comparison to percentage value reported in (Rini et al., 2013) for developing countries. Percentage by weight of food and paper was higher and hence can be a good feedstock for production of CH_4 gas. Additionally, food waste comprise of highly biodegradable component which contribute to increase in CH_4 gas production (Hakami et al., 2015). According to (IEA, 2013) organic waste has higher potential of CH_4 generation and it potential can be increased through co-digestion. This not only increase the production amount but also limit the formation of hazardous gas, ammonia (Abdullah et al., 2014; Holliger, 2017; Horváth et al., 2016; Khalid et al., 2011; Mata-Alvare et al., 2000; Zakarya et al., 2013).

Average moisture content in organic waste

Figure show comparatively higher moisture contain in paper and food waste. Moisture contain are directly proportional to stimulation of microbial activity (Rada et al., 2015) and also create less variation in gas production (Gore and Gore, 2012). (Hernández-Berriel et al., 2008; Khalid et al., 2011) agreed that the higher methane production rate occur at 60-70% of humidity. This clearly implies increase of the water content as a major factor in the production of methane gas. In case of the study area the production of the methane gas will be guided by the food waste while the contribution of the other wastes in the production of the methane gas will be comparatively lower.

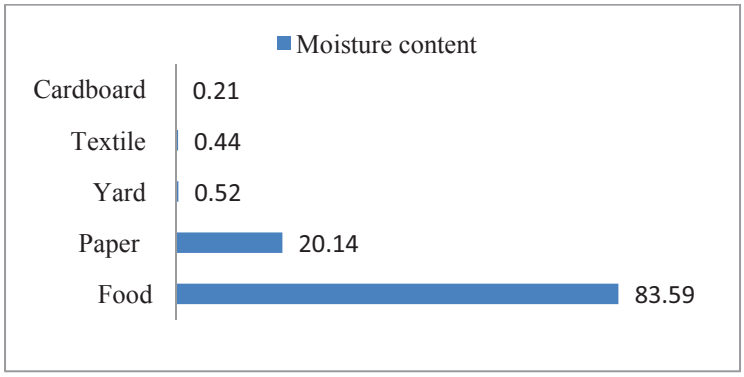

Figure 5 Average moisture content in organic waste.

Empirical formula of waste and its methane generation potential

The chemical composition of the waste (empirical formula) was $C_{367}H_{582}O2_{33}N_{14}S$. At standard temperature and pressure (STP) per amount of the organic material added produce 0.000482219 m^3/kg methane on average.

If all the organic waste gets processed through the A.D process the study area can produce 0.75m^3/kg and 276.13 m^3/kg methane gas per day and year respectively as a maximum production. This can generate the electricity equivalent to 7.56 kwh in a day. Considering this value the organic wastes produce in the area has the potential to generate 2.76MWh electricity in a year.

Conclusion

A.D is the potential alternative solution in addressing municipal solid waste along with production of methane gas. It not only contributes to energy conservation and nutrients production, it also ensures the environmental protection. This study help to identify the energy value of solid waste in terms of methane generation. Generated methane gas can be utilize as an alternative source of energy to lessen the energy crisis problems.

Recommendation

- This type of project can be replicated in municipality level
- Source segregation system should be implemented to achieved the better result in energy production
- Other wastes containing energy value can be exploited
- People need to made aware of economic value of the produced wastes

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Synthesis and Characterization of Activated Carbon Zeolite Composite from Coal Fly Ash for Pb (II) removal from Aqueous Solution

Mahesh Regmi and Vinay Kumar Jha*
Central Department of Chemistry, Tribhuvan University,
Kirtipur, Kathmandu, Nepal
Author correspondence: regmimahesh25@gmail.com

Abstract

The present work deals with the preparation of activated carbon zeolite composite by activating Coal Fly ash (CFA) with Sodium hydroxide at 650 ºC in N_2 atmosphere followed by heating at 80 ºC for 24 hrs. The heavy metal removal performance of the obtained fly ash based zeolite was investigated in Lead (II) removal experiments. The activated carbon zeolite composite were characterized by XRD analysis, FTIR and methylene blue adsorption method. The AAS was employed for Pb analysis. For Lead (II) ion adsorption, the effect of pH, initial concentration and reaction time were studied. The optimum pH for Lead (II) ion adsorption was found to be 6. The equilibrium monolayer adsorption capacity calculated from Langmuir model was 270.270 mg/g. The kinetics data fit well to pseudo second order model. The results of the present study suggest that zeolites can be used beneficially for the removal of Pb (II) from aqueous solution.

Keywords: *Activated carbon-zeolite composite; Adsorption isotherms; Coal Fly ash; Lead (II) ion; Rate constant.*

1. Introduction

The backbone of modern civilization and industry is based on thermal power, heat and energy in various forms. The energy industry is by far the biggest in the world. In the energy industry, coal powered thermal plants is one of the major players. It is also one of the major polluters in the world. As in any chemical industries there are multiple polluting items and agents hence cannot be generalized. In light of that the key polluting waste generated in thermal plants is identified as coal fly ash (CFA) [Heidrich et al; 2013]. There are several impacts of CFA into terrestrial ecosystem. Leaching of toxic elements into soil and ground water. The toxic elements may enters plants through ground water and contaminate the whole food cycles of plants, animals, humans and fishes [Jankowski et al; 2006]. The dumping of CFA in ash damps and ponds has direct effects in aquatic life because of ground water pollution. The primary change associated with water chemistry includes pH variations and increase in concentrations level of toxins in water [Blissett et al; 2012].The management of CFA becomes both economic and environmental issues. Several technological options have been proposed for the disposal of fly ash such as the use of raw materials substitute in the cement production. As the major component of CFA is amorphous aluminosilicate, the conversion of CFA to zeolite has been proposed as a viable method. This is not only to generate a useful adsorbent but also to increase the value of industrial waste CFA [Panitchakarn et al; 2014]. Zeolites are crystalline inorganic polymer, or better said

three dimensional porous aluminosilicate compounds, consisting of 3-dimensional arrangement of $[SiO_4]^{4-}$ and $[AlO_4]^{5-}$ polyhedral connected through their oxygen atoms to form a negatively charge lattice due to isomorphous substitution of Si^{4+} by Al^{3+}. In order to maintain electro neutrality mobile counter cations are stored in an intravoidal water of the zeolite solids [Chunfeng et al; 2009]. The general formulas of zeolites are expressed below:

$$M_{x/n}\,[(AlO_2)_x \cdot (SiO_2)_y] \cdot w\,(H_2O)$$

Where M is a cation of valence n that balances the negative charges associated with the aluminum tetrahedral, the terms x and y correspond to the stoichiometric coefficients of the alumina and silica tetrahedral and w is the number of water molecules.

Zeolites are categorized into natural and synthesized types. Usually, synthesized zeolites are preferred over natural ones due to the possibility of adjusting their pore size through different synthesizing techniques. Different zeolites are synthesized from CFA among which A, X and Y are more valuable because of their extensive catalytic application in detergent, petroling refining and petrochemical industries. The two most common methods available for this conversion are hydrothermal method and fusion method where the fusion method has advantages on the speed of the reaction and the purity of the final products whereas the hydrothermal provides a more consistent pattern of zeolite products [Pavasant et al; 2010].

Lead is recognized as a longstanding environment pollutant. It can be found in waste water generated by various industries such as bullet and shot, fusible alloys, acid battery, ceramics and glass manufacturing, metal planting and finishing, printing, tanning and production of lead additives for gasoline [Momcilovic et al; 2011]. Discarded electrical and electronic products are called e-waste and lead is the typical representative of e-waste which has generated both toxic and valuable materials for society [Ji et al; 2012]. Lead acid batteries are the important source of lead as water pollutant in Nepal due to its growing use especially after the government's encouragement to use solar power in an attempt to save electricity. Improper dumping of such used lead acid batteries can contaminate the surrounding environment with lead [Sherchand et al; 2014].

In the present study we have investigated the conversion process of CFA into the composite of activated carbon zeolite. The Pb (II) ion removal characteristics of thus obtained composite materials were examined.

2. Materials and methods

2.1. Preparation of Activated carbon zeolite

For the synthesis of zeolite, CFA was obtained from Uma-Maheshwor brick factory of Kathmandu valley. This CFA will be ground manually to obtain fine powder form by using mortar and pestle. It was sieved with a Tyler sieve of 75 micron mesh to obtain fine particles. The CFA was mixed with NaOH with varying mass ratio 1:2 and fired at 650 ºC for 1 h in a N_2 atmosphere in a tubular furnace (F21130-33, Thermolyne, USA). After the NaOH treatment, the mixture was ground and suspended in 12 ml deionized water in order to maintain NaOH concentration of 4M. The slurry was sealed in a microwave grade bottle and heated in a furnace at 80 ºC for 24 hrs. Then, the sample was washed several times using deionized water, dried at 50 ºC overnight, and then collected for characterization.

2.2. Chemicals and instruments

All the chemicals used for this are of LR/AR grades and were used without further purification. The distilled water was used to prepare stock solution of Lead (II). All the working solutions were prepared by diluting the stock solutions with distilled water. Digital pH (54/A-3, Accumax, India) was used to measure pH value of solutions. Solutions of 0.1 M NaOH and 0.1 M HCl were used to adjust pH of solutions. The adsorption experiments were carried out by using shaker (AI-153, Accumax, India). The concentration of Pb was determined by AAS (AA-7000, Shimadzu, Japan).

2.3 Adsorption Experiments

Adsorption of Pb (II) ions was studied by batch adsorption experiments using aqueous solution of metal ions taken in a 50 mL stopped conical flasks. The flasks were agitated on shaker for identified time intervals.

The amount of Pb (II) ions adsorbed at equilibrium Q_e (mg/g) was calculated using the equation

$$Q_e = \frac{(C_i - C_e)V}{W} \quad \cdots\cdots \quad (1)$$

Where C_i and C_e are initial and equilibrium concentration of metal ions (mg/L) respectively, W is the mass of adsorbent and V is the volume of solution.
The percentage of removed metal ions in solution is calculated by using the formula

$$Removal\ \% = \frac{C_i - C_e}{C_e} \times 100\% \quad \cdots\cdots \quad (2)$$

The specific surface area of activated carbon zeolite was found to be 241 m^2/g by methylene blue adsorption method.

3. Results and Discussion

3.1. X- ray diffraction (XRD) Analysis

The XRD patterns of the coal fly ash and its NaOH treated sample are show in figure below. XRD is used to determine the crystallinity of zeolite.

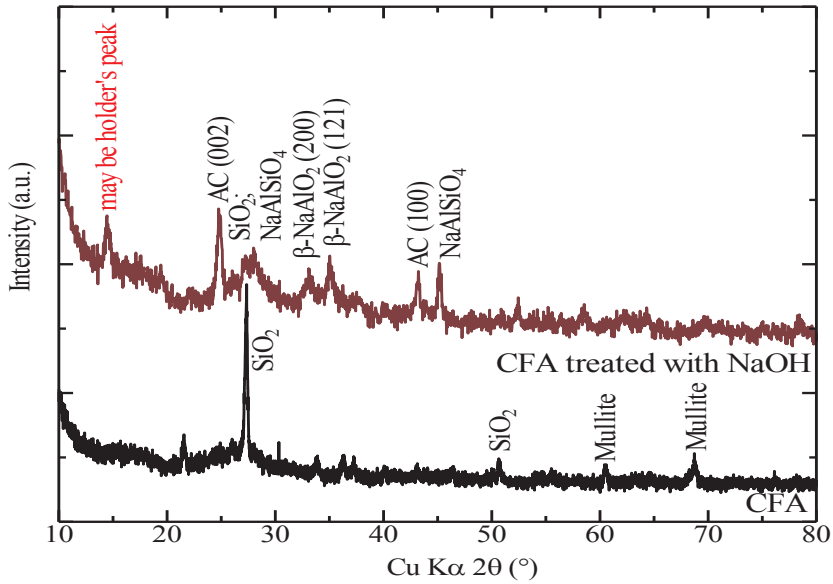

Fig. 3.1: X-Ray diffraction patterns of coal fly ash (CFA) and its NaOH treated samples

Coal fly ash normally contains SiO_2 and mullite ($3Al_2O_3 \cdot 2SiO_2$) phases. The major components SiO_2 and mullite ($3Al_2O_3 \cdot 2SiO_2$) along with unburned carbon were activated by NaOH fusion treatment at 650 °C in a N_2 atmosphere. It was the target to synthesize zeolite sample from coal fly ash but in absence of autoclave the exact product was not obtained. Due to the absence of the calibration of XRD instrument in order to get exact peaks below 2θ value of 10° and the exact characterization of XRD peaks, it is difficult to say whether the any type of zeolite was formed or not. But from XRD pattern it can be seen that NaOH was reacted with aluminosilicate available in coal fly ash and thus $NaAlO_2$ (2θ = 33° and 35°) as well as $NaAlSiO_4$ (2θ = 26-29° and 45°) were formed. The presence of activated carbon is also seen in the XRD pattern.

3.2 FTIR Analysis

The FTIR spectrum of activated carbon zeolite is shown in Fig. 3.2.

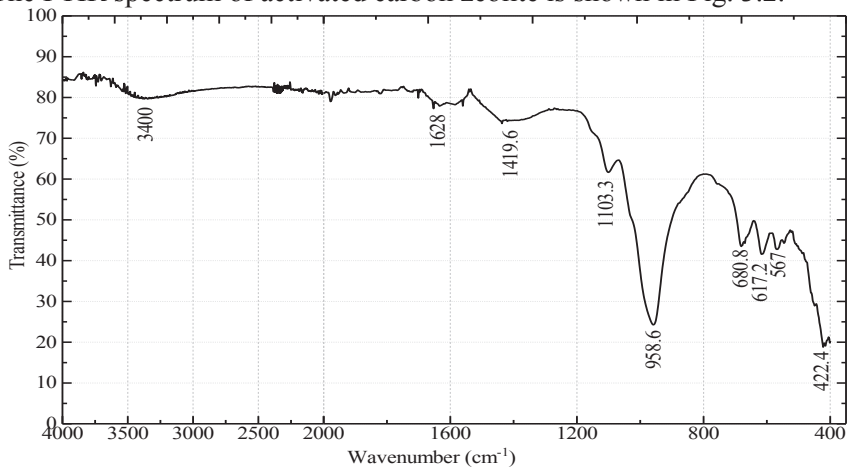

Fig. 3.2: FTIR spectrum of NaOH treated with coal fly ash sample

The FTIR spectra were obtained to understand the nature of functional group present in activated carbon zeolite sample. It indicates weak and broad bands in the region of 4000-400 cm^{-1}. The broader bands in the wave number region at 3400 cm^{-1} corresponds to the symmetric and asymmetric stretching vibration of OH group. The peak appearing at 2000 cm^{-1} may be of residual water.

The peak at 1628 cm^{-1} is due to symmetric stretching of the C=O groups. The peak at 1419.6 corresponds to aromatic carbon–carbon (C=C) stretching vibration. The peak at 958.6 cm^{-1} corresponds to the asymmetric stretching vibrations of Si-O-Si bonds or Al-O-Al bonds or Si-O-Al bonds. The peak at 680.8 cm^{-1} corresponds to the symmetric vibration of internal tetrahedral (Al-O-Al bonds or Si-O-Si bonds). Band at 567 cm^{-1} can be ascribed to double ring mode of external linkage of zeolite framework. The band at about 422.4 cm^{-1} can be assigned to O-Si-O (or O-Al-O) bending vibration in internal tetrahedral [Huiping et al; 2014].

3.3 Effect of pH

The effect of pH on adsorption process is illustrated in Fig. 3.3 which shows the relationship between adsorption (%) and the initial pH in the adsorption of Lead (II) ion onto activated carbon zeolite at the initial concentration of 25 ppm (mg/L). In the study of adsorption of Lead (II) ion the pH was varied from 2 to 8. The maximum adsorption percentage was found at pH 6, which was 94.00 %. Hence the pH 6 was designed as optimum pH. The removal efficiency was poor in acidic environment due to the instability of zeolite framework at lower pH. At low pH, some functional groups may be positively charged and their interaction with metal ion can be hindered significantly. So the adsorption of Pb (II) ion onto activated carbon zeolite at lower pH decreases.

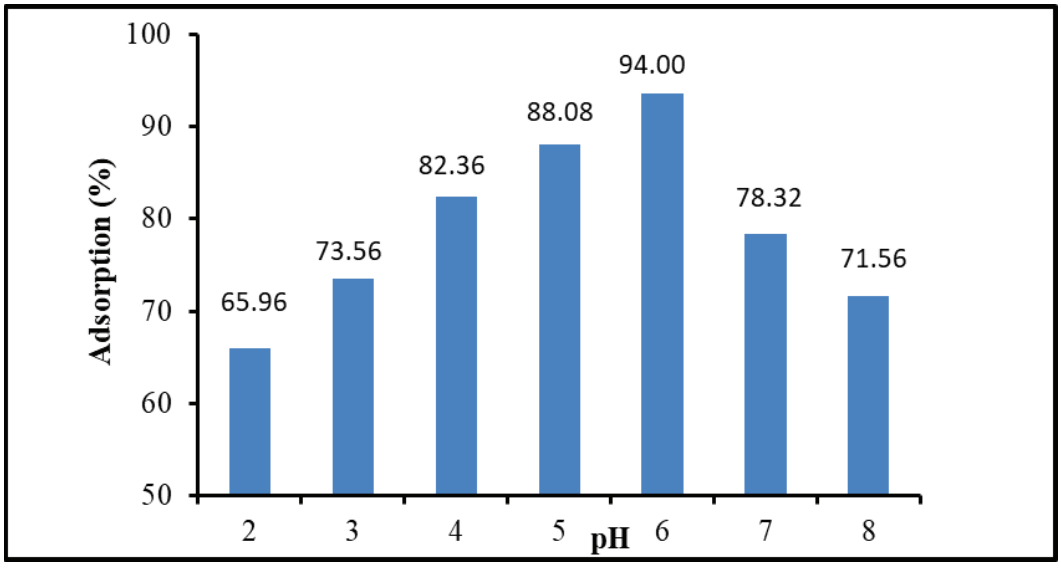

Fig. 3.3: Adsorption of Lead (II) with the variation of pH of the solution.

3.4 Adsorption Isotherm

The adsorption isotherms of Pb (II) were simulated by the mathematical equations of Langmuir and Freundlich. The Langmuir model assumes that the removal of metal ions occurs on a homogenous surface by monolayer adsorption and predicts a linear relation between (C_e/Q_e) and C_e.

$$\frac{C_e}{Q_e} = \frac{1}{Q_m b} + \frac{1}{Q_m} \cdot C_e \qquad \cdots\cdots\cdots \qquad (3)$$

Where Q_e is the adsorption capacity in mg/g at equilibrium; C_e is the equilibrium concentration in mg/L; Q_m is the maximum adsorption capacity corresponding to complete monolayer coverage mg/g and b is the Langmuir adsorption equilibrium constant in L/mg.On the other hand, the Freundlich model, which assumes the surface heterogeneity and exponential distribution of active sites, provides an empirical relationship between the adsorption capacity and equilibrium constant of the adsorbent. The mathematical representation of this model is

$$log\ Qe = log\ K_F + \frac{1}{n}\ log\ Ce \qquad \cdots\cdots\cdots \qquad (4)$$

Where, Q_e is the amount of adsorbate adsorbed per unit mass of adsorbent (mg/g), C_e is the equilibrium concentration of the adsorbate (mg/L); 'K_F' and 'n' are Freundlich equilibrium coefficient, which are considered to be the relative indicators of adsorption capacity and adsorption intensity[Jha et al; 2008].

The Pb (II) uptake experiments were performed with initial Pb (II) concentrations ranging from 25 to 600 mg/L. The parameters calculated from the Langmuir and Freundlich equations using the experimental data are listed in Table 1. The solid and broken curves in Fig. 3.4 are calculated from the resulting Langmuir and Freundlich parameters. The correlation coefficient value indicates the superiority of Langmuir model over Freundlich model.

Table 1: Langmuir and Freundlich parameters

Langmuir Model					Freundlich model			
Q_{max} (mg/g)	b (L/mg)	R^2	ΔG (kJ/mole)	χ^2	K_F (L/g)	n	R^2	χ^2
270.27	0.077	0.9997	-24.00	0.880	40.93	2.90	0.9186	7.163

The Langmuir constant b is related to the free energy change of adsorption (ΔG, kJ/mol) according to the following formula [Aryal et al; 2011]

$$\Delta G = -RTln(b) \qquad \cdots\cdots\cdots \qquad (5)$$

Where, R = Universal gas constant (8.314 $Jmol^{-1}K^{-1}$) and T = Temperature in Kelvin. The Gibbs free energy indicates the degree of spontaneity of the adsorption process, negative value reflecting a more energetically favorable adsorption process. The (ΔG) value obtained from Eq. 5 is negative, confirming the feasibility of the adsorbents and the spontaneity of the adsorption process. The

value of ΔG confirms the adsorption process is favoured by physio-chemical adsorption. The value of χ^2 for the Langmuir model is smaller than that of the Freundlich model which concludes that adsorption of Lead (II) on activated carbon-zeolite follows the Langmuir adsorption isotherm.

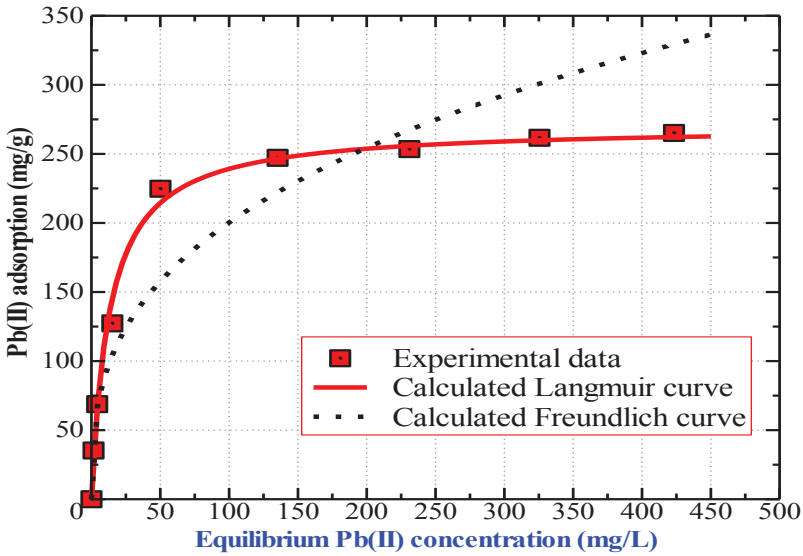

Fig 3.4: The adsorption isotherm of Pb (II) onto activated carbon-zeolite

3.5 Adsorption kinetics

In order to investigate the rate law describing the adsorption of Pb (II) onto activated carbon zeolite, the kinetics data obtained from the batch experiments were analyzed using two kinetics equations namely the pseudo first- order equations proposed by Lagergren and the pseudo-second order equation proposed by Ho et al. The linear form of pseudo-first order and pseudo second order model is given below

$$log(Qe - Qt) = logQe - \frac{K_1}{2.303}t \quad \cdots\cdots \quad (6)$$

$$\frac{1}{Q_t} = \frac{1}{K_2 Q_e^2} + \frac{1}{Q_e}t \quad \cdots\cdots \quad (7)$$

Where Q_e is the amount of metal adsorbed at equilibrium (mg/g) and Q_t is the amount of metal ion adsorbed at any time 't' (mg/g). Similarly, K_1 is the rate constant of pseudo-first order adsorption (per minute), K_2 is the pseudo-second order rate constant (mg/g/min) [Jha et al; 2008]. The correlation coefficient values in Table 2 of pseudo-first order and pseudo-second order models are 0.9397 and 0.9984 respectively showed that the kinetics of Pb (II) onto activated carbon zeolite followed pseudo-second order kinetics.

Table 2: Kinetics parameters of Pb (II) adsorption on activated carbon zeolite

Pseudo first order model			Pseudo second order model		
Q_e (mg/g)	K_1 (min^{-1})	R^2	Q_e (mg/g)	K_2 (g/mg.min)	R^2
13.24	0.0278	0.9397	35.33	0.0056	0.9984

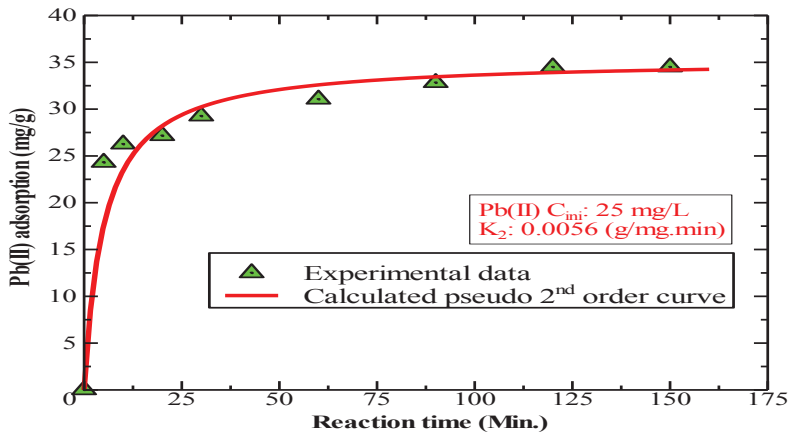

Fig 3.5: *The plot of adsorption of Pb (II) onto activated carbon zeolite as a function of time*

It is very clear from the graph that the equilibrium reached in 120 minutes. It was found that the adsorption rate was rapid at first and then slowed down near the equilibrium state. After reaching the saturation point there was no significant change in the rate. The initial rapid increase in the rate was due to the availability of more number of active sites so that large number of Pb (II) got attached to adsorbent sites. As the time passed the number of active sites became less and finally the equilibrium state was obtained.

4. Conclusions

The composites of activated carbon zeolite can be prepared from coal fly ash. These composites materials have good adsorption characteristics with adsorption isotherm of Langmuir type. The maximum adsorption capacity of Pb (II) onto activated carbon-zeolite calculated from Langmuir model was 270.27 mg/g. The equilibrium contact time was found to be 120 minutes following the pseudo-second order kinetics model with rate constant value of 0.0056 g/(mg min). The value of ΔG obtained from Langmuir equation was -24.00 kJ/mole. The negative value of free energy (ΔG) in adsorption process reveals the spontaneous nature and feasibility of the adsorption process for the adsorption of Pb (II) onto activated carbon- zeolite. The value of ΔG confirms the adsorption process is favored by physio-chemical adsorption.

5. Acknowledgements

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Acknowledgements

Acknowledge the person/s and or institution/s, if necessary, who actually help to achieve the objectives of the research.

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Book:

• Miller Jr. GT and Spoolman SE. 2012. Living in the environment. 17th ed.Thompson Steele, Inc., Canada. 446pp.
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- Use standard abbreviation such as g for gram and cm for centimeter and so on.
- Use realistic formatting not the artistic formatting without giving any jargons and complexity.
- For table, graph and figures use title casesuch as Figure 1.Protected Areas in Nepal.
- Do not merge unnecessary rows and column in the table to make more complex formatting.
- Try to be realistic and straight forward to describe findings.
- Do scientifically whatever you want to do.
- Follow the rules of standard journal such as Agronomy Journal of America etc. to write scientific paper.

Language:

Language of the article should be English. Articles in other language will not be accepted.

Font:

- Times New Roman:
- Title 14 font (Bold), Sub title: 12 font bold, Text 12 font not bold, all non-capitalized

Before you submit:

Ensure that the following items are checked:

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