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Environmental Pollution Control and Monitoring Section
SahidSukra Marg, Kupondole, Lalitpur
Nepal

REPORT
on
Brick Kiln Stack Emission Monitoring in Kathmandu Valley

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Executive Summary

Pollutions related to air, water, soil, noise and municipal wastages have been primary environmental concerns in Kathmandu Valley. Their apparent effects are largely realized from policy level to the implementation levels. In order to minimize the problems, both legal and implementation aspectsshould be made stronger within the framework of Government Policy, Act, Regulations, Standards and Guidelines. In addition to the Environment Protection Act (1997) and Environment Protection Rules (1997), the Constitution of Nepal has also emphasized on the right to clean environment.The Government of Nepal has promulgated the standards on Chimney Height and Emission for the Brick Kiln Industries on B. S. 13 Falgun 2064 (25 Feb 2008). Ministry of Population and Environment (MoPE) working on new standards for Brick Emission standards in very near future promulgated.

Brick making is one of the traditional crafts in Kathmandu Valley. Brick is a primary building material in many parts of Nepalin Kathmandu Valley and in the southern plains of the Terai. Clay is the main raw material for brick making which is available locally atvery low cost. Coal is the main fuel used and it isimported from India. Apart from coal, a small fraction of sawdust, fire-wood, bagasse and agriculture residue are also used as fuel in these kilns. Brick making is an energy and labour intensive process. Hand moulding of green bricks is widely practiced in Nepal and there is no mechanization of this process (except for large Hoffman Kiln units and few FBTK). The industry is seasonal and operates for about 6-7months from November to May except for large mechanized kilns with shades for storing bricks.

The use of large quantities of coal in brick kilns contributes significantly to emissions of carbon dioxide (CO_2), particulate matter (PM) including black carbon (BC), sulphur dioxide (SO_2), oxides of nitrogen (NOx), and carbon monoxide (CO). The pollutants not only have an adverse effect on the health of workers, local population, and vegetation, but also contribute to global warming.Coal is a combination of different chemical components, which produce heat in exothermic reaction. Some components of the coal i.e. ash do not produce any heat but after combustion it remains in the kiln. Ash can be divided into two types namely fly ash and bottom ash. Fly ash is the one of the pollutants which is emitted as SPM through flue gas. Along with fly ash un-burnt carbon is also emitted through flue gas. Due to un-burnt carbon, flue gas can be seen as black in colour. Energy efficient kiln can achieve 100 percent elimination of un-burnt carbon and can also reduce the fly ash percentage.

New technologies such as the Vertical Shaft Brick Kiln (VSBK),Tunnel Kilns and Hybrid Hoffmann Kiln (HHK) are substantially cleaner than the currently used Fixed BTK (FBTK). These improved technologies consume less energy and emit lower level of pollutants and greenhouse gases.

During the study,30 brick kilns were visited in Kathmandu, Lalitpur and Bhaktapur Districts. About 110brick kilns (Kathmandu- 15, Lalitpur – 32 and Bhaktapur – 63) are in operation in Kathmandu Valley. Among the 30 brick kilns 1 VSBK, 1 Hoffmann and 28 BTK (Induced Draft) technology adopted. Most of the BTK brick kilns were adopted Zig-Zag setting pattern for green brick stacking to kiln. Most of the Induced BTK wereconverted from natural BTK. Induced BTK is energy more efficient and less polluting technology compare to the Natural ones.Most of the

industries did not have any recorded information and data. Pollution control devices have not been installed by any brick kilns, but some simple steps have been taken into considered during kiln construction and operation by some. Most of the kilns haveadapted the zig-zag setting which helps in complete combustion of fuel.

Most of the visited kilns were using a coal as main fuel, only a very small percentage uselocally available fuel. Total 9334 workers are working in the industry of which are 2772 females. The visited 30 kilns have to produce 1691 lakhs capacity bricks per year but they actually produced 1449 lakhs i.e. 86% of the capacity in last FY. These industries were using coal as the main fuel, consuming 12,409 tons of coal and 1881 tons of other local fuels

Mostly unskilled workerswere seen to be involved in the operation. Besides the stack emission, dust generated during different works and blown due to air movement was also seen as major issues to the employees and neighboring residence. Wind breakers were not seen in any of the brick kilns.

SPM Concentration of all types of technology of brick kilns are found to be well below the existing promulgated standards. Brick kilns have improved their operating practices over the last years; they are now more energy efficient and have also reduced the SPM emission compared to the previous years. Some of the industries have already installed the gravity settling chamber. However, although most kilns meet the national standards, black smoke is still seen in some chimneys during firing. Average SPM concentration of BTK was 326 mg/Nm3; VSBK was 144 mg/Nm3 and Hoffmann was 374 mg/Nm3. These values **are** withinthe current standards**.**
However, they are not in level of the proposed standards (the standard currently under process for enforcement) and also not in level of the existing brick kiln technology that have emerged in the world. Comparative to India and China Standards these kilns were emitting much higher level of pollutants.

Most of these kilns have not adopted any pollution control measures.We recommend to immediately promulgate the new proposed standards. The following vital recommendation will help the brick kiln to comply with the new emission standard.

- Effective policies and regulations need to be developed and practiced so that brick industries will start to adopt energy efficient and less polluting technologies like Zig Zag Kiln, Tunnel Kiln, and HHK.
- Compulsorily use at least 40 % coal as an internal fuel in all brick kilns.
- Use alternative locally available low Sulphur containing fuel instead of imported coal.
- establishing the demand/market for resource efficient products like hollow and perforated bricks, and limiting the production of solid bricks in phases.
- Adoption of improved feeding, firing and operating practices in existing FCBTKs.
- Fix coal Standards for Coal and import only high GCV values and less ash/sulphur containing Coal.
- encourage to introduce large-scale brick producing kilns with cleaner technologies.

- Retrofitting of existing FBTK kiln and converting into High Draft Kiln with zig zag firing.
- Make it mandatory that temperature indicator and pressure gauge are installed in the chimney.
- Make it mandatory that Brick kilns install Temperature gauge in firing zone, flue duct and chimney to monitor and control the combustion process.
- Make it mandatory that double walled insulated feedhole covers to prevent heat loss from fuel charging holes in the bull's trench kilns.
- Make it mandatory that FBTK construct double walled wicket and between the walls filled with ash it helps to control the leakage and heat loss.
- Make it mandatory that FBTK top insulation is in the minimum 7-inch-thick toprovide heat insulation.

Fugitive Dust Emission Control

Besides SPM emission from flue gas, fugitive dust generations were also core issues in the kilns. The following recommendation will help to control the generation of fugitive dust in brick kilns:

- Crushing of coal should be done in an enclosed equipment/ area to avoid process emissions.
- Following measures should be adopted to control dust emissions due to airborne ash from the top of brick settings:
  - ✓ Raising a 2 feet wind breaker wall along the outer trench wall of FBTK.
  - ✓ Covering of the top ash layer in the preheating zone with sheet in FBTK.
  - ✓ Introduction of Insulated Blanket instead of Rapish for Insulation of top of the kiln.
- The approach road and the road around brick kiln should be paved/stabilized.
- Water should be sprinkled frequently over roads around brick kiln and over the ash layer before its removal and transfer.
- Two or three rows of trees should be planted along the outer periphery of kiln area.

कार्यकारी संक्षेप

हावा, पानी, माटो, ध्वनि संबन्धि प्रदुषण र शहरी फोहोरहरु काठमांडौ उपत्यकाका प्राथमिक वातावरणीय चासोहरु भएका छन् । यिनका प्रत्यक्ष असरहरु नीतिगत देखि कार्यान्वयनका तहहरुसम्म ठूलो मात्रामा अनुभव गरिएका छन् । यी समस्याहरुको समाधानका लागि, कानुनी र कार्यान्वयन दुबै पक्षहरुलाई सरकारी नीतिनियम, ऐन, मापदण्ड र निर्देशिकाका खाका भित्र बलियो बनाइनु पर्छ । वातावरण संरक्षण ऐन (१९९७) र वातावरण संरक्षण नियमावली (१९९७) का अतिरिक्त नेपालको संविधानले पनि स्वच्छ वातावरणको हकलाई जोड दिएको छ । नेपाल सरकारले इटा भट्टा उद्योगहरुको लागि बि।स। २०६४ फाल्गुन १३ (२५ फेब्रुवरी २००८) मा चिम्नीको उचाइ र धुवाँ निष्कासनको मापदण्ड निर्धारण गरेको छ । जनसंख्या तथा वातावरण मन्त्रालयले इटा उद्योगको धुवाँ निष्कासनका लागि निकट भविष्यमानै नयाँ मापदण्ड निर्धारण गर्ने तर्फ काम गर्दैछ ।

इटा निर्माण काठमाडौं उपत्यकाको एउटा परम्परागत कला हो । इटा काठमाडौं उपत्यका लगायत नेपालका धेरै भुभागहरु र तराइको दक्षिणी मैदानमा भवन निर्माणको आधारभूत सामाग्री हो । इटा निर्माणको लागि आवश्यक मुख्य कच्चा पदार्थ माटो हो जुन सस्तो मुल्यमा स्थानिय रुपमै उपलब्ध हुन्छ । मुख्य रुपमा प्रयोग गरिने इन्धन कोइला हो जुन भारतबाट आयात गरिन्छ । कोइला बाहेक केहि मात्रामा काठको धुलो, दाउरा, उखुको छोक्रा, र कृषिजन्य उपजहरु पनि इटा भट्टामा इन्धनको रुपमा प्रयोग गरिन्छ । इटा निर्माणमा उर्जा र श्रम अधिक प्रयोग हुने गर्दछ । नेपालमा काँचो इटा हातैले बनाउने चलन नै अधिक प्रयोगमा छ र यसको कुनै यान्त्रिक प्रकृया छैन (ठूला होफम्यान भट्टि इकाइहरुमा र केहि एफबिटिकेमा बाहेक) । यो मौसमी उद्योग हो र इटा भण्डारणको लागि छानोको ब्यवस्था भएका ठूला यान्त्रिक भट्टिहरु बाहेक अरु सबै नोभेम्बर देखि मे सम्म ६-७ महिनामात्र संचालित हुन्छन् ।

इटा भट्टाहरुमा ठूलो परिमाणमा कोइलाको प्रयोगको कारणले गर्दा उल्लेख्य रुपमा कार्बनडाइअक्साइड र कालो कार्बन, सल्फरडाइअक्साइड, नाइट्रोजनका अक्साइडहरु र कार्बनमोनोक्साइड समावेश भएका पार्टिकुलेट पदार्थहरु निष्कासन हुन्छन् । यी प्रदुषकहरुले कामदारहरु, स्थानिय वासिन्दा र वनस्पतिहरुको स्वास्थ्यमा प्रतिकुल असर पार्नेमात्र नभइ ग्लोवल वार्मिंगमा पनि सहयोग पुर्याउँछन् । कोइला एउटा विभिन्न रासायनिक हिस्साहरुले बनेको पदार्थ हो, जसले वाह्यतापिय प्रतिकृयाबाट ताप उत्पादन गर्छ । कोइलाको केहि हिस्साहरु जस्तै खरानीले कुनै ताप उत्पादन गर्दैन तर प्रज्वलन पछि यो भट्टिमै रहिरहन्छ । खरानीलाई उड्ने र तल बस्ने गरि दुइ किसिममा विभाजन गर्न सकिन्छ । उड्ने खरानी ती प्रदुषकहरु मध्य एक हो जुन एसपिएमको रुपमा धुवाँसंगै निष्कासन हुन्छ ।उड्ने खरानीसंगै नजलेको कार्बन पनि धुवाँसंगै निष्कासन हुन्छ । नजलेको कार्बनले गर्दा धुवाँ कालो रंगको देखिन्छ । उर्जा किफायति भट्टाले शतप्रतिशत नजलेको कार्बन हटाएर उड्ने खरानीको प्रतिशत पनि घटाउन सक्छ ।

Vertical Shaft Brick Kiln (VSBK), Tunnel Kilns and Hybrid Hoffmann Kiln (HHK) जस्ता नयाँ प्रविधिहरु अहिले प्रयोगमा रहेको Fixed BTK (FBTK) भन्दा धेरै मात्रामा सफा छन् । यी सुधारिएका प्रविधिहरुले कम उर्जा खपत गर्दै थोरै मात्रामा प्रदुषकहरु र हरितगृह ग्यासहरु निष्कासन गर्छन् ।

अध्ययनको क्रममाकाठमाडौं, ललितपुर र भक्तपुर जिल्लाका ३० वटा इटा भट्टाहरुको भ्रमण गरिएको

थियो । काठमाडौं उपत्यकामा झण्डै ११० इटा भट्टाहरु (काठमाडौं - १५, ललितपुर - ३२, भक्तपुर - ६३) सञ्चालनमा छन् । ती ३० इटा भट्टाहरुमा १ले VSBK, १ले Hoffmann र२८ले BTK (Induced Draft) प्रविधि अपनाएका छन् । प्रायः BTK इटा भट्टाहरुले काँचो इटा थाक लगाउन Zig-Zag सेटिंग ढाँचा अपनाउँछन् । प्रायः Induced BTK हरु प्राकृतिक BTK बाट रुपान्तरण गरिएका थिए । Induced BTK प्राकृतिक BTK को तुलानामा बढि उर्जा किफायति र कम प्रदुषणकारी प्रविधि हो । प्राय सबै उद्योगहरुसंग जानकारी र तथ्यांकको अभिलेख थिएन । कुनै पनि भट्टाहरुले प्रदुषण नियन्त्रणका उपकरणहरु जडान गरेका छैनन्, तर थोरैले भट्टा निर्माण र सञ्चालनको क्रममा केहि साधारण उपायहरुलाई ध्यानमा राखेका छन् । प्राय भट्टाहरुले zig-zag सेटिंग अपनाएका हुन्छन् जसले इन्धन पुर्ण रुपमा बल्न मद्दत गर्दछ ।

निरिक्षण गरिएका प्राय भट्टाहरुले कोइलालाई मुख्य इन्धनको रुपमा प्रयोग गरिरहेका थिए, एकदमै कमले मात्र स्थानिय रुपमा उपलब्ध इन्धन प्रयोग गर्दथे । जम्मा ९३३४ कामदारहरु यस उद्योगमा काम गर्छन् जस मध्य २७७२ महिला छन् । निरिक्षण गरिएका ३० भट्टाहरुले वार्षिक १६९१ लाख इटा उत्पादन गर्नु पर्नेमा गत आर्थिक वर्ष १४४९ लाख मात्रै उत्पादन गरे, जुन पूर्ण क्षमताको ८६% मात्र हो । यी उद्योगहरुले १२,४०९ टन कोइला र १८८१ टन स्थानिय इन्धन खपत गर्दै कोइलालाई मुख्य इन्धनको रुपमा प्रयोग गरिरहेका थिए ।

कार्या संचालनमा मुख्यतया अदक्ष कामदारहरु संलग्न भएका देखिन्थे । निष्कासनको थुप्रो बाहेक, विभिन्न कामहरुको सिलसिलामा जम्मा भएको धुलोलाई हावाले उडाइदिंदा त्यो कामदारहरु र छिमेकका वासिन्दाहरुको मुख्य चासोको विषय बनेको देखिन्थ्यो । हावा ब्रेकरहरु कुनै पनि भट्टामा राखिएको थिएन ।

एसपिएमको मात्रा हाल निर्धारित मापदण्ड भन्दा सबै प्रविधिका इटा भट्टाहरुमा धेरै तल रहको पाइयो । इटा भट्टाहरुले आफ्नो संचालन प्रकृयामा विगतका वर्षहरुमा सुधार गरेका छन्; अघिल्ला वर्षहरुको तुलनामा ती अझ बढि उर्जा किफायति भइ एसपिएम निष्कासनमा कमि पनि ल्याएका छन् । केहि उद्योगहरुले ग्र्याभिटि सेटलिंग च्याम्बर पनि जडान गरिसकेका छन् । तैपनि, सबैजसो भट्टाहरुले राष्ट्रिय मापदण्ड पुरा गरेका भएपनि, आगो लगाउँदा केहि चिम्नीहरुबाट कालो धुवाँ निस्किएको अझै देख्न सकिन्छ । औसत एसपिएमको मात्रा बिटिकेको ३२६ mg/Nm3; भिबिएसकेको १४४ mg/Nm3 र होफम्यानको ३७४ mg/Nm3 रहेको छ । यी मानहरु हालको मापदण्ड भित्रनै पर्दछन् ।

तैपनि, यी मानहरु प्रस्तावित मापदण्डको स्तर अनुसार छैनन् (अब लागु हुने अहिले प्रकृयामा रहेको मापदण्ड) र विश्वमा अहिले प्रयोगमा आइरहेका इटा भट्टा प्रविधिको स्तरका पनि छैनन् । भारत र चीनको मापदण्डसंग तुलना गर्दा, यी भट्टाहरुले धेरै ठूलो मात्रामा प्रदुषकहरु निष्कासन गरिरहेका थिए ।

सबैजसो भट्टाहरुले कुनै पनि प्रदुषण नियन्त्रणको तरिका अपनाएका छैनन् । हामी तत्काल नयाँ प्रस्तावित मापदण्ड घोषणा गर्न सुझाव गर्दछौं । नयाँ निष्कासनको मापदण्ड पालन गर्नको लागि इटा भट्टाहरुलाई यी सुझावहरुले मद्दत गर्ने छ ।

- इटा उद्योगलाई उर्जा किफायति र कम प्रदुषणकारी प्रविधिहरु जस्तै नागवेली भट्टि, टनेल भट्टि, र एचएचके अपनाउनको लागि प्रभावकारी नीति र नियमहरुको विकास तथा अभ्यास गर्नु आवश्यक छ

।

- सबै इटा भट्टाहरुमा आन्तरिक इन्धनको रुपमा कम्तिमा ४०% कोइलाको प्रयोग अनिवार्य गर्नु ।
- आयातित कोइलाको सट्टामा स्थानिय रुपमा उपलब्ध कम गन्धकको मात्रा भएको इन्धन प्रयोग गर्ने ।
- चरणबद्ध रुपमा ठोस इटा उत्पादनलाई घटाउँदै लगि स्रोत किफायति उत्पादनहरु जस्तै खोक्रो र प्वाल परेका इटाहरु माग\बजार स्थापित गर्ने ।
- हालका एफसिबिटिकेहरुमा सुधारिएको फिडिंग, फाइरिंग र संचालन अभ्यासहरु अपनाउने ।
- कोइलाको स्तर कायाम गरि उच्च जिसिभि मान र कम खरानी\गन्धक भएका कोइलामात्र आयात गर्ने ।
- सफा प्रविधियुक्त र ठूलो परिमाणमा इटा उत्पादन गर्ने भट्टाहरु प्रयोगमा ल्याउन प्रोत्साहन दिने
- हालका एफबिटिकेहरुलाई प्रवलीकरण गर्दै नागवेली फाइरिंग भएको हाइ ड्राफ्ट भट्टिमा रुपान्तरण गर्ने ।
- चिम्निमा तापक्रम सुचक र प्रेसर गेज जडान अनिवार्य गर्ने ।
- प्रज्वलन प्रकृयालाई नियन्त्रण तथा रेखदेख गर्न सबै इटा भट्टाहरुका फाइरिंग जोन, फ्लु डक र चिम्निमा तापक्रम गेज जडान अनिवार्य गर्ने ।
- बुल्स ट्रेन्च भट्टाहरुमा इन्धन चार्जिंग होलहरुबाट तापक्रम घट्नबाट जोगाउन दोहोरो पर्खाल लगाएर फिडहोल कभरहरु इन्सुलेट गर्नु अनिवार्य गराउने ।
- तापक्रम गुम्न र चुहावट नियन्त्रणमा मद्दत गर्न एफबिटिकेलाई दोहोरो गारोको विकेट र गारोको बिचमा खरानीले भर्नु अनिवार्य गर्ने ।
- तापक्रम चुहावटबाट जोगाउन एफबिटिकेको टुप्पोको इन्सुलेसन कम्तिमा ७ इन्च मोटो बनाउन अनिवार्य गर्ने ।

अनियन्त्रित धुलो निष्कासन नियन्त्रण

फ्लु ग्यासबाट एसपिएमको निष्कासनको अलावा अनियन्त्रित धुलोको उत्सर्जन पनि भट्टाहरुको प्रमुख समस्या थियो । इटा भट्टाहरुमा अनियन्त्रित धुलो उत्सर्जनको नियन्त्रण गर्न यी सुझावहरुले मद्दत गर्ने छन्ः

- प्रोसेस इमिसन हटाउनको लागि कोइला तोड्ने काम बारिएको उपकरण वा क्षेत्रभित्र गरिनु पर्छ ।
- ब्रिक सेटिंगको माथिबाट हावामा उड्ने खरानीको कारणले निष्कासन हुने धुलो नियन्त्रण गर्न देहाय बमोजिमका तरिकाहरु अपनाइनु पर्छः
    - ü एफबिटिकेको बाहिरि ट्रेन्च पर्खालसंगै २ फुटको विन्ड ब्रेकर पर्खाल उठाउने ।
    - ü एफबिटिकेको प्रिहिटिंग क्षेत्रमा रहेको माथिल्लो खरानीको तहलाई तन्नाले ढाक्ने ।
    - ü भट्टाको टुप्पो इन्सुलेट गर्न रापिसको सट्टामा इन्सुलेटेड ब्ल्यांकेट प्रयोगमा ल्याउने ।
- इटा भट्टा पुग्ने र त्यस वरिपरीको सडक पक्कि\कालोपत्रे गरिनु पर्छ ।
- इटा भट्टा वरिपरीको सडक र खरानीको तह हटाउनु र अन्यत्र लैजानु अघिसम्म निरन्तर रुपमा पानी छर्किइरहनु पर्छ ।
- भट्टा क्षेत्रको बाहिरी सिमानासंगै दुइ वा तीन लहर रुखहरु रोपिनु पर्छ ।

Abbreviations

APP	:	Agriculture Perspective Plan
BC	:	Black Carbon
BTK	:	Bull's Trench Kilns
CBS	:	Center of Bureau Of Statistics
CEQ	:	Council On Environmental Quality
CO	:	Carbon Monoxide
CO_2	:	Carbon Dioxide
CP	:	Cleaner Production
DCSI	:	Department of Cottage and Small Industries
DG	:	Diesel Generator
EIA	:	Environmental Impact Assessment
EIS	:	Environmental Impact Statement
EPA	:	Environment Protection Act
EPI	:	Environment Performance Index
EPR	:	Environment Protection Regulation
ESPS	:	Environment Sector Program Support
FBTK	:	Fixed Chimney Bull's Trench Kilns
FSMP	:	Forestry Sector Master Plan
GCV	:	Gross Calorific Value
HHK	:	Hybrid-Hoffman Kiln
IEE	:	Initial Environmental Examination
IT	:	Information Technology
MBTK	:	Moving Chimney Bulls Trench Kilns
mg/Nm^3	:	Milligram per Normal Meter Cube
MoSTE	:	Ministry of Science, Technology and Environment
MOPE	:	Ministry of Population and Environment
NCS	:	National Conservation Strategy For Nepal
NEIA	:	National Environmental Impact Assessment
NEP	:	National Environmental Policy
NEPA	:	National Environmental Policy Act
NEPAP	:	Nepal Environmental Policy And Action Plan
NOx	:	Oxides Of Nitrogen
PM	:	Particulate Matter
SDC	:	Swiss Agency For Development And Cooperation
SO_2	:	Sulphur Dioxide
SPM	:	Suspended Particulate Matter
VDC	:	Village Development Committee
VSBK	:	Vertical Shaft Brick Kiln

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Chapter 1: Background

1.1 Introduction

Protection of human health through preserving our lovely planet is one of the primary obligations for all countries. Environment is a cross-cutting issue which covers the total of all surroundings of a living organism, including natural forces and other living things. In present days, the promotion of environmental friendly activities through awareness and implementation as well as enforcement to the concerned agencies has becoming widely realized interventions.

Brick making is one of the main industrial activities in Nepal. Major brick clusters in the country are located mainly in Kathmandu valley and the Terai region. Various types of brick making technologies are practiced in Nepal. These vary from simple intermittent type manual operations to continuous type and semi-mechanized ones.

Coal is the main fuel used for baking brick. It is supplemented to a very minor ratio by various agricultural residues such as husks, bagasse, etc. Ash is one of non-combustible material, which exists in the fuel. Its percentages vary according to the type of fuel. In the coal, firewood and biomass ash percentage is very high. Brick kiln operates with the help of draught through chimney. Flying particles of ash and un-burnt coal come out through chimney and are emitted to the environment. This pollutes the environment. These particulates are suspended in the air and are called Suspended Particulate Matters (SPM).

Brick industries can be recognisedbytheprominent height of the stack (Chimney). In Nepal most of brick kilns are named with chimney Bhatta or chimney Itta udhyog. Chimney is technically required in brick kilns because; it creates draught and also disperses pollutants and flue gases in environment. Although kilns have been mainly constructed in the terai and the Kathmandu valley,these have now been constructed in nearby districts of Kathmandu valley as well. The height of chimney in the hilly areas is not making any meaningful effect for dispersion of emission, as most brick kilns have been installedin lower levels,whereas people’sresidence is usually at higher level.

Figure 1: BTK in Valley

Government of Nepal "Ministry of Environment (MOE)" has fixed the "Standard on Chimney Height and Emission for Brick Kiln Industry", published in Falgun, 13 2064. The Government of Nepal is aware of the serious environmental problems created by the brick kilns. However, the Kiln ownersare apprehensive of the Act because of the increasing cost of production. Efforts have been intensified by environmental watchdog organizations and activists, who are going hand in hand with communities to limit the growth of kilns and force them to "clean up" or "close down".

1.2 Nepal Environmental Policy and Action Plan (NEPAP)

Government of Nepal hasadopted the Nepal Environmental Policy and ActionPlan (NEPAP) to show its firm commitment to integrate environmental concernswith development objectives, and to address environmental problems. This policyhas specified five main objectives as follows:

- To manage efficiently and sustainably natural and physical resources
- To balance development efforts and environmental conservation for sustainable fulfilment of the basic needs of the people
- To safeguard national heritage
- To mitigate the adverse environmental impacts of development projects and human actions
- To integrate environment and development through appropriate institutions, adequate legislation and economic incentives, and sufficient public resources.

1.3 Environmental Protection Act and Environmental Protection Rules, 1997

The act has made it mandatory thateither Environmental Impact Assessment (EIA) orInitial Environmental Examination (IEE) (depending upon the size) is conducted and apply for approval from the Ministry of Population and Environment(MOPE) or Concerned Agency forimplementation of proposals that haspotential adverse impacts on environment asspecified in the Annex – 1 and Annex – 2 of the EPR (Clause 3 to 6 of EPA). Some of the highlights of the Act are as follows:

Clause 7 of the Act has the following provision:

1. No one shall generate 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.

2. If it appears that anyone has carried out any act in contrary to sub-section (1) and caused significant adverse impacts on the environment, the concerned agency may prescribe necessary terms in regard thereto or may prohibit the carrying out of such an act.

3. If it appears that the use of any types of substance, fuel, tools or device has caused or is likely to cause significant adverse impacts on the environment, the Ministry may, by a notification in the Nepal Gazette, shall forbid the use of such substance, fuel, tools or device.

4. Other provision relating to the prevention and control of pollution shall be as prescribed.

The Act also has the provision to appoint Environmental Inspectors for ensuringmitigation, prevention and control of pollution. In such way DoE appoints Environmental Inspectors and they have the authority to inspect, test or examine premises, machinery, equipment, vehicles, documents or goods.

Clause 11 of the Act has the provision to establish different laboratories or tospecify existing laboratory for the carrying out works to facilitate environmentalprotection and pollution control.

Similarly, Clause 12 of the Act requiresconcerned person, institution or proponent to allow authorized person to collectsamples of wastes from industrial units, machinery, and vehicles etc. for study,test or analysis.

Clause 13 has the provision of Environment Protection Fund.
Clause 15 provides for additional Incentives and Facilities for positive response toenvironment by industry, business or process.
As per the Clause 16, formation of different committees with concerned experts – scope of work, responsibilities and authorities may be specified.
Clause 17 of theAct provides for claim of compensation for any loss or damage due to pollution.
Clause 18 has the provision of punishment for carrying out activities withoutapproval or in contrary to approved proposal. Such activity can be closedimmediately and the person or agency carrying such activities may be fined up toNPR 100,000/-

1.4 Environmental Impact

Based on observations of Kathmandu and nearby areas, it can be inferred that Nepal is facing a very serious environmental degradation, including severe air and water pollution. The air in the capital city is heavily polluted so much so to effect the visibility. People living in Kathmandu Valley are suffering due to the high levels of PMs, SO_2, NOx, Ozone, benzene, and other aromatic hydrocarbons. A large number of the residents wear masks on the streets. The pollutants arise mainly from vehicles, poor road condition, and surrounding industrial units. Water in the rivers is thick, dark and black, emitting a nauseating rotten smell. Rivers have become disposal sites for sewage water and all kinds of municipal solid wastes. Highly contaminated water runs all the way to downstream areas.

Pollutants from brick kilns are affectingthe respiratory system of the exposed groups; it also reduces the agricultural yields, and makes the country less attractive to tourists. As a country whose economy heavily relies on agriculture and tourism, Nepal cannot sustain its development and economic growth in this manner.

“The Environment Performance Index (EPI) ranking 2012” conducted by the Yale Centre for Environmental Law and Policy, Yale University and Centre for International Earth Science Information Network and Columbia University—has listed Nepal in the third last position (the 130th) among 132 countries scoring 18 out of 100 points provided for air pollution, in terms of air pollution impact on human health, and in the 104^{th} position in terms of impact of water pollution on human health. The bottom four countries in this ranking of air pollution impact on human health are all from South Asia - Pakistan (129), Nepal (130), Bangladesh (131), and India (132). Particulate matter and indoor air pollution levels serve as indicators for the impact of air pollution on human health, raising alarms about the gravity and urgency of the air and water pollution issues in the South Asia Region.

Fugitive Dust in Brick Kiln **Black Smoke Emission**

Figure 2: Pollutants from Brick Kiln

Brick sectoris a major coal-consuming sector in Nepal and also the second largest single source of air pollution after transport in the Kathmandu Valley. According to the Program and Technology Background Information of the VSBK Program of GoN and the Swiss Agency for Development and Cooperation (SDC), the brick sector contributes about 30% of air pollution in the Valley.

It is estimated that brick kilns are major contributor of CO_2emission to the environment.Brick kilns are also a major source of black carbon emission, which is alleged to be one of the significant contributors to the melting of snow and glaciers of the Himalayas.

1.5 Department of Environment

In order todisseminate the concept of environmental management to grass root level so as to resolve the problems created by climate change caused by anthropogenic factor; to coordinate between governmental, nongovernmental and private organizations and to effective monitoring of environmental management, Government of Nepal established the Department of Environment (DoE) in 27 July 2012 (as of 12 Shrawan 2069 BS) under the Ministry of Science, Technology and Environment (MoPE). Ever sinceits establishment, it has shown its presence in both national and international levels. It is widely believed that the Department will be instrumental in dealing with the environmental related issues and maintaining and enhancing the quality of environment for descent life and livelihood through promotional and enforcement related efforts.

1.6 Objectives of the study

The main objective of the current consulting activities is to monitor the existing emission levels from brick kilns of Kathmandu Valley. However, the following are the specific objectives of the activities:

- To monitor the stacks emissions of brick kilns of Kathmandu valley.
- To analyse the samples after monitoring in laboratory.
- To calculate the values of particulate matter with reference of Nepal Standards.
- To compare the result with published and proposed standards of the Ministry of Population and Environment
- To provide recommendation for reduction of existing emission levels.

1.7 Scope of the Work/activities under the contract:

The consultancy firm/organization in close co-ordination with DOEnv shall take the overall responsibility for organizing and carrying out all activities in the field and producing the report. The tasks envisaged from the consultancy firm/organization are:

Existing Situation

- Baseline study: Following baseline study shall be done during this work:
  - ✓ Data on
    - o the number of Brick Kilns,
    - o fuel types used in these emission sources, year of installation, capacity, cost and location
    - o Different pollutants generated throughout (over) the Fiscal Year (Preferably for last five years).
  - ✓ Review of
    - o the existing policies, legal framework
    - o Existing regional and international practices
    - o System of Brick Kiln registration in Nepal.
    - o Energy or fuel consumption per metric tons' emission generated

- Conduction of field studies in the different sources for the following aspects
  - ✓ To monitor 30 brick kiln stacks in Kathmandu valley by including all the three districts in the valley.
  - ✓ Detailed observation of various areas/sources and types of controls adopted to pinpoint specific problem areas and causes of emissions. Number of brick kilns in the valley adopting pollution control measures
  - ✓ Generation of domestic data through stack measurement such as flow, pressure, particle size distribution, dust concentration etc. and of data/information from international organizationsthrough literature survey.

  - Analysis of the collected samples for the purpose of estimation/quantification and characterization of the emissions as per the identified suitable methods.
  - General overview of criteria/practices and proceduresfollowed by the concerned government authorities while providing permission for installation, operation, phasing-out of different Types of Brick Kiln.

  - Analyse and compare the monitored data's and secondary data of brick kilns emission according to the published standard by Ministry of Population and Environment and review the existing executive standard and make recommendation of amendment if any.

Literature Review/Comparative Study

- Literature survey on emissions control practices adopted within Nepal and overseas.
- Review of regulation/standards/guidelines for emissions from Brick Kiln elsewhere equally applicable to Nepal especially to Kathmandu Valley. Include

the current situation of the developed, emerging and developing countries as much as possible.

- Examine the legal requirements pertaining to implementation Brick Kiln Standard
- Compilation of stack measurement data from the literature search.
- To provide awareness to each monitored brick kilns how to reduce emissions from the kilns without compromising quality and capacity.

1.8 Limitation of the work

The limitations of the work in this study have been presented below:

Due to limitation of the budget and as per the scope of work under the Terms of Reference, for the primary data, there was provision for drawing and testing of emission samples from only thirty brick kilnsfrom Kathmandu Valley. Also only one sample was drawn and tested from each of the thirty brick kilns from the Valley. Only very few of the brick kilns have installed samplingport, platform and ladder in the Chimney for drawing the samples of emissions. This has limited the number of kilns from which samples couldbe drawn.

1.9 Methodologies of Study

1.9.1 Selection of Brick Kilns

Brick kilns were selected in the 1st steering committee meeting covering all the three districts of Kathmandu Valley and all currentlyoperated technologies.

1.9.2 Stack Emission and Height Measurement

The following methods were used for monitoring and analysis of brick kilns emission

1. Site selections
2. Velocity Measurements
3. Sampling and Analysis

Sampling point selections

The site was selected wherelaminar flow of air is present in the stack. To ensure the laminar flow, the sampling port was prepared and located at a point, which wasin between 8 times the chimney diameter from the top and 2 times the diameter form the bottom to avoid any flow disturbance. For the rectangular cross section, the equivalence diameter (D_e) has to be calculated from the following equations to determine upstream, downstream distances

D_e = 2 LW/ (L+W)

Where L= Length in m, W = Width in Metres

Figure 3: SPM Monitoring

Velocity measurements

With help of stack velocity meter:The velocity of the flow of draught in the chimneywere measured with a velocity meter that was capable of measuring the velocity from 0.2 m/s to 20.0 m/s.

Temperature measurement:
Temperature of the stack was measured with help of stack velocity monitor equipment which had the facility of a thermocouple with digital pyrometer.

Calculations for velocity
Velocity (v) = K x 2√ H x Ts
Where, v = velocity (m/s)
K = Pitot calibration constant
H = differential mm hg H2O
T_s = Stack Temperature ^oK

The stack gas density is a function of the molecular weights of gases comprising the flue gas, the static pressure inside the chimney and the temperature of flue gas. To be scientifically exact, the partial fractions of the major constituents of the flue gas were determined to estimate the molecular weight of the components of the flue gas. Similarly, the static pressure and stack gas temperature are measured before the velocity of smoke stream inside the stack was determined.

However, molecular weight of the stack gas is practically the same as that of air, while the static pressure is close to the atmospheric pressure. Hence the stack gas density was approximated by the following relationship equation without significant errors;

$$D_s = D_a^* Ta/Ts$$

The velocity measured is averaged out by determining the velocity at different points across the cross-section.

Correction for ISOKINETIC Sampling
The measured velocity was used to calculate the ISOKINETIC sampling rate for a known nozzle. However, the stack gases cool down as they pass through the sampling train and the rate of flow indicated in the stack sampler was correspondingly corrected as per the gas law.There will alsobe a pressure drop across the sampling train. So that for an exact measurement of the flow rate, corrections for the changes in both pressure and temperature have to be made.

Sampling with stack sampler
The sampling of particulate matters was done in iso-kinetically. The instrument had measuring system for gravimetric determination of the dust content in flue gas. Dust-laden gas is extracted iso-kinetically by means of the filter head probe. The dust was retained by a dust collector with a plane filter and is subsequently weighed. The nozzle size of the dust collector was selected according to the calculated velocity and dust collectiondata was noted on data collection form. Stack temperature was measuredbefore selection of the filter paper for sampling.

Calculations

SPM (mg/ m^3) = Weight of dust Collected (mg)/Volume of air sampled (m^3)

(*This value is then converted into mg/N m^3: following were used formula for the conversion.)*

$$P \cdot V = n \cdot R \cdot T$$

$$\frac{P \cdot V}{T} = \text{constant}$$

$$\frac{P_0 \cdot V_0}{T_0} = \frac{P_1 \cdot V_1}{T_1}$$

$$V_0 = V_1 \cdot \frac{T_0 \cdot P_1}{T_1 \cdot P_0}$$

$$V_{(0^o C, 1013\, mbar)} = V_{(T,P)} \cdot \frac{273[K] \cdot P[mbar]}{T[K] \cdot 1013[mbar]}$$

$$C_{ref.} = \frac{21 - O_2\ \%_{(ref.)}}{21 - O_2\ \%_{(measured)}} \cdot C_{measured}, \text{ where}$$

$C_{ref.}$	=	concentration at reference O_2% [mg/normal $m^3_{(ref.)}$]
$C_{measured}$	=	measured concentration [mg/normal $m^3_{(measured)}$]
$O_2\ \%_{(ref.)}$	=	reference O_2% [Vol%]
$O_2\ \%_{(measured)}$	=	measured O_2%[Vol%]

Carbon dioxide Measurement

Fyrite kit was used to measure oxygen and carbon dioxide in chimney. The Fyrite kit hadprovision to measure the CO2 and O2 and display reading immediately.

Height Measurement

The height of the chimney was measured with the help of Clinometer. Angle of Clinometer determined from one distance (d) from base of the chimney. The following formula was used to determine chimney height.

X (m) = Tan (angle) x d
Total Height of Chimney = X + eyes Height (m)

Where,
X = height of chimney from eyes height

Chapter 2: Overview of Brick Sector in Kathmandu Valley

2.1 Brick Kilns in Kathmandu Valley

Brick making is one of the main industrial activities in Kathmandu valley. It is estimated that about 110brick kilns (2 Hoffmann, 1 VSBK and 107 BTK) are in operation in Kathmandu Valley. The capacities of these Kilns are ranging about 30 lakhs to 2.5 crore bricks per year. The Kathmandu Valley brick industry is unorganized with production units clustered in 3 core areas of Kathmandu, Lalitpur, and Bhaktapur districts of the valley. The brick making season in Kathmandu Valley is generally 160 – 200 days in a year. Industry associations for these three districts do exist, however their role is limited to price fixing and lobbying for tax concessions etc.

Table 1: Brick Kilns in Kathmandu Valley

Kiln Type	Average Production (Millions bricks per year)	Number of Kilns
BTK Fixed Chimney (Induced Draught)	612	107
Hoffmann	40	2
VSBK	8	1
Total	**660**	**110**

Coal is the main fuel used which comes from in India. Apart from coal, a small fraction of sawdust, Lapsi seed, Bagasse and agriculture residue are also used as fuel in these kilns. There is no prevalent practice of mixing coal dust/ other fuel in the green brick making process. The average coal consumption in Kathmandu is around 56,100 tons/year and other local fuels 330 tons/year.

Majority of the brick kilns are situated on leased lands and utilize clay from nearby agricultural land / fields. Once the clay is exhaustedthe kiln is purchased and transport from other places. Hand moulding of green bricks is widely practiced in Kathmandu Valley and there is no mechanization of this process (except for large Hoffman Kiln units). The industry is seasonal and operates for about 6 months from December to June.

Brick making is an energy intensive process and consumes about 56.1 thousand tonnes of coal and 330 tonnes of biomass fuels per year in Kathmandu valley alone. Within the valley, this sector has become the single largest consumer of coal. The share of energy in the total cost of brick production is 30 to 40%. With regards to Kathmandu valley, the soil here is considered to be of very good quality for brick making.

The sector provides employment to about 25,000 workers, however, as the sector is unorganized these figures are much higher. Almost 98% of the skilled man power in these kilns (i.e. those related to firing & brick stacking) are from neighboring India. The Nepalese workforce in these kilns is used for hard physical labor relating to the green brick making process and loading and unloading to bricks from the kilns. Most of them are migratory workers and some are from the farming community of the location where the kiln is located.

The brick sector is highly labor intensive apart from the Hoffman kilns and VSBK that have a certain degree of mechanization. Even in these, the mechanization is only related to green brick making process.

At present Fixed Chimney BTKs (FBTK) is widely used for brick making. There are also some Vertical Shaft Brick Kiln (VSBK), and Hoffman Kilns. Fixed chimney BTKs (FBTK) was introduced by the brick entrepreneurs after the banning of MBTK by GoN in the Kathmandu Valley in 2002. Such units were transformed into Fixed Chimney BTK.

Despite the importance of the brick sector, about 96 percent of kilns are outdated and use energy-intensive and highly polluting technologies. Those are located near to cities and contribute fine particulate pollution. This causes harmful impacts on health (from particulate matter) and agricultural yields (from nitrogen oxides) locally and contributes to global warming (from carbon dioxide). Kathmandu is recognized as a one of the most polluted cities in Asia. Addressing the impact of brick kilns on pollution in the country as a whole and Kathmandu valley in particular is very important.

Clay is the main raw material for brick making.Itis available locally at a relatively low cost. Coal is the main fuel used and isimported from India. Apart from coal,fuel wood, sawdust, bagasse, agriculture residue areallused as fuel in these kilns contributing a small fraction. Brick making is an energy and labour intensive process. Hand moulding of green bricks is widely practiced and there was no mechanization of this process except for large Hoffman Kiln units and few FBTK.

There are distinctly two types of brick industries in Valleynamely machine made bricks and handmade bricks. Most of the units in the valley have handmade green brick making units. Moving chimney Bull's Trench Kilns are no more seen in Kathmandu Valley.

The use of large quantities of coal in brick kilns contributes significantly to emissions of carbon dioxide (CO_2), particulate matter (PM), including black carbon (BC), sulphur dioxide (SO_2), oxides of nitrogen (NOx), and carbon monoxide (CO). The pollutants not only have an adverse effect on the health of workers, local population, and vegetation, but also contribute to global warming.

New technologies, such as the Vertical Shaft Brick Kiln (VSBK) Tunnel Kilns and the Hybrid Hoffmann Kiln (HHK), are substantially cleaner than the Fixed BTK (FBTK) currently used. These improved technologies consume less energy and emit lower levels of pollutants and greenhouse gases (GHGs) (BUET 2007; Heirli and Maithel 2008; World Bank 2011a).

2.2 Registration of Brick Kilns and Relevant Legislations

Most of the brick industries in Nepal qualify as small industries as per Industrial Enterprise Act 2049 code 5 and therefore fall within the jurisdiction of the Department of Cottage and Small Industries (DCSI) underthe Ministry of Industry, which is responsible for verifying the Initial Environmental Examination (IEE) or Environmental Impact Assessment (EIA) required of any brick kiln and subsequently for making a decision on the license application. A no objection letter, on the behalf of local community and local government administration, from the village development committee (VDC) or municipality of the area, where the kiln is to be located is also necessary for the license application to be considered.

In addition, DCSI has beentasked with the monitoring of brick kilns for complaints of adverse environmental impacts and for making recommendations to the Industrial Promotion Board, which decides onindustrial policy, on any concessions or incentives that may be granted to cottage and small industries. The Ministry of Population and Environment (MoPE) plays an important role in regulating the brick sector with respect to environment protection and pollution control: it is charged with issuing pollution standards and monitoring to ensure compliance with those standards.

A number of regulations, such as the Environment Protection Act 1997, Environment Protection Regulation 1997, Industrial Enterprises Act 2049, and Industrial Policy 2067, have general provisions to promote cleaner technology and energy efficiency, provisions that apply to the brick sector as well. There are also Government initiatives that apply specifically to the brick sector. Table 5 presents a list of Government decisions pertaining to the brick sector and the promotion of cleaner technologies in the sector. Perhaps the most significant of these was the decision in 2009 to replace all MBTK in the country within two years (by the end of 2011) with modern kilns, where the category has been defined to include VSBK, FBTK, and Tunnel Kilns.

Some districts have been granted a one year extension of time to comply with this directive (FNBI, 2012). This decision was preceded seven years earlier with the ban on clamp kilns and M-BTK in the Kathmandu Valley. Furthermore, kilns in the Valley were required to either own a land with a minimum radius of 200 feet from the center of the kiln or have it on rent / lease for a period of at least five years, required to submit plans for mining the soil andthey are prohibited touse firewood, rubber tyresor plastic as fuel.

Table 2 Government Decisions in the Brick Sector

Government Decision	Description
The Industrial Enterprises Act 2049 (1992) Section 15:Sub-section K	Permission shall be granted for a reduction of up to 50 percent from the taxable income for the investment of any industry on process or equipment, which has the objective of controlling pollution or which have a minimum adverse effect on the environment. Such remission may be deducted on a lump-sum or on an instalment basis within a period ofthree years.
The Industrial Enterprises Act 2049 (1992) Section 15:Sub section N	After an industry comes into operation, 10 percent of the gross profit shall be allowed as a deduction against taxable income on account of expenses related with technology, product development and efficiency improvement.
The Industrial Enterprises Act 2049 (1992) Section 16:Sub-section D	On the recommendation of and with the decision of the Council of Ministers, and by notification published in the Nepal Gazette, additional facilities may be granted to any National Priority Industry or any industry established in Nepal by the way of invention therein.
Industrial Policy, 2067	Those industries who adopt environment friendly technology and save energy themselves will be provided

Government Decision	Description
	technical and financial support
Local Self Governance Act, 2055 (1999)	- Section 28.h.3 authorizes VDC to make various programs on environment protection and to carry out or cause to be carried out the same. - Section 28.j.2 authorizes VDC to act as a motivator for carrying out cottage industries in the village development area. - Section 96.c.4 authorizes Municipality to control and prevent, or cause to be controlled and prevented the possible river-cutting, floods and soil erosion in the Municipality area. - Section 96.i.1 authorizes Municipality to act or cause o act as a motivator to the promotion of cottage, small and medium industries in the Municipality area. - Section 189.m authorizes DDC to maintain records of the cottage industries to be establish within the district development area, and to identify and develop an industrial zone in the district.
VAT Act 2052	It states that there exists a threshold limit for compulsory registration under VAT Act for the industries with the turnover of over NPR. 2,000,000/- over last 12 months or turnover of NPR.200,000/- in any month. All the brick industries basically have turnover of more than NPR. 2,000,000 annually. The existing rate for VAT is 13%.
Excise Act, 2058, Schedule in accordance to section 3, (s.no. 25)	It is mandatory for the brick industry to pay excise duty; as the brick (produced within the country or imported) is listed as the excisable goods under this section.
Excise Duty Regulation, 2059, Schedule 2, (3, G, 2)	Excise duty is waived for the brick kiln producing bricks using the modern technology and emitting under the Nepal emission standard.
Excise Rule (10th Amendment), 2066 (2009 /10), Schedule 2, 3,G	It states that NRs.150,000 per kiln as excise duty for the brick industry, and for the brick kilns out of the valley there is 25% deduction in this amount
Excise Duty Regulation,(10th Amendment),2009/10,S schedule 2, (explanation)	Brick kilns registered for VAT do not need to pay excise license fee amount. However, if the brick kiln pays VAT amount less than the amount of excise duty then the brick kiln should pay the remaining amount as excise duty. (e.g. If a brick kiln pays NRs. 75000 as VAT now, the brick kiln should pay remaining NRs. 75000 as excise duty)
Industrial Promotion Board meeting 15/12/2009, 183 minutes, decision no. 1	Decided to replace the existing MBTK within 2 years by VSBK/Fixed Chimney/Tunnel Kiln. Mandatory to use the VSBK/Fixed Chimney/Tunnel Kiln for new registration, compulsory EIA for industries producing more than 20 million bricks per year and IEE mandatory for industries producing less than 20 million. The Forest Distance for VSBK has been removed.

Source: Winrock (2011

Some other policies also support the introduction of cleaner kiln technologies. For example, in 2010, the Department of Forest (DoF) classified VSBK as a technology that is not reliant on wood, therefore exempting VSBK from having to seek permission to operate from the local District Forest Office (previously VSBK was required to maintain a 2 km distance from the nearest forest).

Similarly, DCSI’s working guidelines stipulate different requirements for distance from populated areas, height of chimneys and land requirement for Bull’s Trench Kiln and VSBK technologies, recognizing the superior environmental performance of VSBK. The lower emission level permitted by the Ministry of Environment for VSBK as compared to BTK technologies, however, while acknowledging differences between the technologies and promoting efficiency improvement within technologies, fails to provide incentive for switching from more polluting technologies to less polluting ones.

Despite the presence of numerous Government initiatives to promote cleaner brick firing technologies the current operation practices gives the impression of active engagement and enforcement has remained lax. The large number of brick kilns that operate on an informal basis is particularly problematic when it comes to the monitoring and enforcement of regulations. It is widely acknowledged that the nationwide ban on MBTK has not been effective thus far. It took some time for the ban on MBTK in Kathmandu Valley to become successful. Many of the regulations, especially those calling for positive interventions are vague so as to make evaluation of implementation difficult. Any financial incentives, such as excise duty exemptions have been of such a low magnitude that they have not had the desired effect.

Chapter 3: Technologies Adopted in Brick Kiln of Kathmandu Valley

Three kiln technologies are in operation in Valley, as presented in Table 3. The FBTK is a dominant technology adoptedby 107 Kilns,i.e. 97 percent of the total. It is very polluting and relatively inefficient in terms of energy consumption. The Hoffmann kilns and the VSBK kilns are substantially cleaner, but represent just a small percentage.

Table 3 Existing brick kiln technologies

Kiln Type	Number	Percentage of Total Kilns,(%)	Brick Production (million bricks)	Percentage of total production (%)
FBTK	107	97.3	612	92.7
VSBK	1	0.9	8	1.2
Hoffmann	2	1.8	40	6.1
Total	**800**	**100**	**660**	**100**

Source: FNBI

3.1 Fixed Chimney Bull Trench Kiln (FBTK)

FBTK is the mainstay technology for the brick sector in Nepal. It is highly polluting, energy intensive but requires relatively low-cost investment. The FBTK emit black smoke because of incomplete combustion of coal. It is based on the traditional BTK technology, which dates back to the 19^{th} century. Two kinds of FBTK are operated in Nepal i.e. FBTK (Natural Draught based) and FBTK (Induced Draught based). FBTK (Induced) was seen much cleaner than the FBTK (Natural) because of efficient draught control system available in induced draught based.

The FBTK has an elliptical shape and measures about 250 ft long and 60 ft wide. It is constructed mostly in open fields either over ground or partially underground. The bottom and the sidewalls are lined with bricks. The FBTK uses green bricks that are manually produced from mud processed in pug mills. The wet green bricks are sun dried and loaded in the kiln in a standard way developed over time with provisions for airflow and coal stoking. Once the green bricks have been loaded in the kiln, the top is covered with two layers of bricks and dirt for insulation

Both types of FBTK still suffers from incomplete combustion of fuel, indicated by high CO concentration in flue gas (PPM range), black smoke, and un-burnt coal deposition at the floor of the kiln. The incomplete combustion of fuel results in high SPM and BC emissions in flue gases.

Fixed Chimney Kiln (FBTK)

- The Fixed Chimney Kiln (FBTK) is a newer version of the traditional Bull's Trench Kiln (BTK)
- The standard kiln measures 250 ft x 60 ft
- It is almost 200 years old technology and shares about 88% of Nepal's total brick kilns and 97 % in Kathmandu Valley
- The bottom and the sidewalls of the kiln are lined with bricks with the top left open
- The chimney is fixed and varies between 120 and 130 feet

- The flue gas exhausted by installation of Induction fans.

3.2 Hoffmann Kiln

Hoffman kiln also known as annular kiln was invented by Fulvic Dolly who is a German; in 1858 AD.The Hoffman kiln design is a product of continuous firing kilns. Because of its simple structure, low investment, it has been widely used in the world. With the progress of modern science and technology, it is difficult for Hoffman kiln to realize mechanical operations to some degree.

It is being eliminated in the foreign countries progressively, but in China it still plays an important role in brick making industry. Hoffman kiln has a continuous annular channel, the straight portion is the straight section of the kiln, and the semi-circular part is the curved section of the kiln. Kiln Road is through; Install a kiln door used for transporting green bricks or finished brick. Set up a kiln room or a door in the corresponding area between two neighbouring kiln.

The scale of the Hoffman kiln is calculated based on the number of the kiln room or kiln door. One fire door kiln usually has 16 to 22 doors, two fire door kilns usually has 32-40 doors, three fire door kilns generally has 54 to 60 doors. The Hoffman kiln is composed of kiln channel, kiln door, coal cast hole, the main smoke discharging channel, the tributary smoke discharging channel, the smoke discharging hole. The main smoke discharging channel is located along the entire path between the longitudinal direction of the kiln channel, the smoke discharging hole is located at the lower part of the kiln room.

Figure 4: Hoffmann Kiln in Valley

The main smoke discharging channel and the smoke discharging hole is connected by tributary smoke discharging channel. The main smoke discharging channel and the tributary smoke discharging channel is connected by cast iron conical valve. The main smoke discharging channel is equipped with chimney or smoke discharging fan. The main smoke discharging channel can also be led to the outer part of the kiln by underground smoke discharging channel, and then to the chimney or smoke discharging fan. The smoke discharging system is composed of smoke discharging hole, tributary smoke discharging channel, main smoke discharging channel, and chimney(smoke discharging fan).

The main advantages of these kilns are as follows:

- Supply of bricks is continuous and regular
- Pre-heating of the bricks are done by hot gases before they escape into the atmosphere
- Fuel consumption and stack emission is low
- Bricks are burnt evenly and the quality of bricks is good
- Sufficient height of the chimney control the emissions of particulates and flue gases
- Kiln is operational throughout the year.

The main disadvantage associated with the Hoffman Kiln is the high capital investment.

Hoffman brick Kiln (without Shade)

Hoffman brick Kiln (Inside Shade)

3.3 Vertical Shaft Brick Kiln (VSBK)

The VSBK is a vertical kiln with stationary fire and moving brick arrangement. The kiln operates like a counter current heat exchanger, with heat transfer taking place between the air (moving upwards) and the bricks (moving downwards). A typical VSBK consists of one or more shafts located inside a rectangular brick structure.

The shafts are 1 to 1.25 meters wide with nominal lengths of 1 m, 1.5m, 1.75m or 2.0 m. *In the 2 pilot VSBKs in Nepal, the shafts are 2 x1 m wide and the shaft height has been set to hold 11batches.* The inside surface is a brick wall, often lined with refractory fireclay bricks. The gap between the shaft wall and outer kiln wall is filled with insulating materials (such as pure "rappish"). Provision for peepholes and thermocouple probes are provided along the shaft height to monitor the position of fire as well as temperature profile of the kiln.

The shaft is loaded from the top in batches of green bricks. Each batch typically contains four layers of bricks set in a predetermined pattern. The kiln itself can be divided into three distinct sections. The top section is the brick preheating zone, the middle section is the firing and heat soaking zone and the lower section is the brick cooling zone.

Fuel is usually added in two forms; internal fuel and external fuel. The internal fuel is added with the soil during prior to brick molding. Different internal fuels used in VSBK are coal powder, fly ash, biomass fuels such as rice husk and bagasse. Only coal is used as external fuel in VSBK. VSBK is a natural draft kiln, requiring no electricity for supply of combustion air. The air required for combustion enters from the bottom of the kiln. It extracts the heat from the cooling bricks before reaching the firing zone.

The perception of VSBK technology in Nepal is mixed.

There are both cases of success and absolute failure. However, the following comments on VSBK are generally consistent:

1) VSBK technology transfer in Nepal has experienced a lot of difficulties. There are still many technical issues yet to be addressed. To scale it up, if expected as the right direction to go, a lot more support is needed;
2) The technology is operationally very sensitive and requires higher management skill;
3) The technology is also very sensitive to the quality of clay;
4) The production capacity of VSBK is too small;
5) Brick quality is low and breakage rate is high;
6) Interest in further investment from entrepreneurs is limited; there is no existing support from the Government for VSBK and further support is very unlikely.

3.4 Comparison of different kiln technologies in Nepal

The comparison of operating technologies in is as follows:

Table 4 Comparison of different kiln technologies in Valley

Parameter		FBTK (Forced Draught)	Hoffmann	VSBK
Land Required	Bigha*	6	4	6
Raw Material and Services	Clay	12,000 tons	30,000 tons	14,400 tons
	Workers	250 (15% skilled, 15% semiskilled)	300 (25% skilled, 45% semi skilled)	150 (25% skilled, 45% semi skilled)
	Electricity	Needed for ID fan	Needed for machine made bricks	Needed for machine made bricks
	Fuel	Coal	Coal	Coal and internal fuel
Fuel Consumption	100,000 bricks	11-12 tons	10-11 tons	10-11 tons
Pollution		20-30% less than FBTK depending upon management	20-30% less than FBTK	40-50% less than FBTK
Production Period		November to April	Round the year	Round the year
Wastage		4-6%	2-3%	2-3%
Scales of Operation		4 million	10 million	4.8 million
Constraints in Operability		- Source of clay - Rain causes extensive loss - Electricity - Diesel - Workers - pollution	- Clay storage for rainy season - High thermal mass kiln takes long time to heat up after shutdown - Large operation - Electricity	- Clay storage for rainy season - High thermal mass kiln takes long time to heat up after shutdown - Electricity
Quality of Bricks		Better than FBTK (N)	Good	Not Acceptable for load bearing
Emission with poor management		High	Medium	Low

*1 bigha= 6772 m^2

Source: Feasibility Study Report of Hybrid Hoffmann Kiln, Ministry of Industry, 2014

Figure 5 Brick Kiln Technologies

3.5 Environmental Performances of Existing Kilns

Most operating brick kilns in Nepal are highly polluting since they use crude technology and low-quality coal for fuel. Burning of coal in the kilns releases various pollutants into the atmosphere, including SPM, sulfur dioxide (SO_2), carbon monoxide (CO), Carbon dioxide (CO_2), and NOx. Among these kiln types, the FBTK releases the highest level of SPM and SO_2, primarily because of high coal consumption and temporary setup. In terms of pollutants, the VSBK and Hoffmann kiln is considerably superior to FBTK.

Pollutants from these kilns contribute to health problems of the exposed population. It increases the adult mortality from cardiopulmonary diseases and lung cancer caused by long-term $PM_{2.5}$ exposures and it also increases the infant and child mortality from respiratory diseases caused by short-term PM_{10} exposure.

After combustion of coal emits CO_2, which contribute to global warming and climate change. Energy inefficient technology like FBTK consumes high quantity of coal resulting higher quantity of CO_2 generation. In addition, low quality coal further increases the CO_2 emissions. Similarly, poor insulation, lack of technical expertise, technicians and heat losses require additional coal, whose use leads to further CO_2 emissions.

Air pollution in the areas where brick kilns are located contributes to the decline of agricultural yields. Evidence of reduced yields from orchards and crops due to air pollution is well-documented. Dust deposition on leaves of plants (i.e., crops and orchards) hinders photosynthesis, which reduces productivity. Acid deposition from the SO_2 and NOx emissions from brick kilns also causes injury to plant tissues, with negative effect on agricultural productivity.

Using of firewood has not been banned in Nepal and it used for brick-making. This can lead to deforestation or forest degradation, with loss of environmental services (e.g., watershed protection) and biodiversity.

3.6 Social Issues

The FBTK kilns usually operate 6-7 months out of the year (from November to May) because most of them depend on season. The involved workers and technicians are from India and marginalized community of Nepal. Local workforces are not interested to work in these kilns because they don't foresee their secure future. The workers are not organized and affiliated to any trade unions for getting their rights. FBTK involve many social issues related to migrant work, gender and child labor, and health and sanitation. The existing scenario of this technology is lacking of labour forces due to unaddressed social issues.

3.7 Occupational Safety and Health

Most of the workers of the kilns are having lack of better alternatives. They usually perform unskilled and low-wages work. They do hard physical labor for long hours (e.g., mud-pugging by foot, brick-molding by hand, and carry head loads of bricks), which can cause severe muscular and skeletal stress. In many cases, workers temporarily migrate with families and take up residence near kilns. The sanitary conditions in such residences are often abysmal. Moreover, the high level of air pollution in the kiln area is a health hazard for workers. Overall, the hard physical labor and unsafe conditions likely cause both short- and long-term health problems for workers (Dinesh Sah 2014). FBTK are using the fine dust containing silica "RAPISH" as an insulating materials and it emits to the working environment which is very hazardous to workers.

Chapter 4: Energy and Environment

Coal is usedas a main fuel in all brick kilns. It is mainly imported from India. Besides coal small fraction of saw dust, vegetable seeds, bagassee and rice husk also using as a fuel. All brick kilns crush the coal to required size for firing. Coal is a combination of different chemicals components which produce the heat in exothermic reaction. Some component of the coal i.e. ash do not produce any heat but after combustion remains in the kilns.

Ash can be divided into two types namely fly ash and bottom ash. Fly ash is the one of the pollutant which is emitted as a SPM through flue gas. Along with fly ash un-burnt carbon is also emitted through flue gas. , Due to the un-burnt carbon, flue gas colour can be seen as black. Energy efficiency in brick kilnscan achieve elimination of un-burnt carbon and also reduce the fly ash percentage.

Coal

Coal

Saw Dust

Lapsi Seed

Figure 6 Fuels using in Brick Kiln

4.1 Properties of Coal

Coal is classified into three major types namely anthracite, bituminous, and lignite. Anthracite is the oldest coal from geological perspective. It is a hard coal composed mainly of carbon with little volatile content and practically no moisture. Lignite is the youngest coal from geological perspective. It is a soft coal composed mainly of volatile matter and moisture content with low fixed carbon. Fixed carbon refers to carbon in its free state, not combined with other elements. Volatile matter refers to those combustible constituents of coal that vaporize when coal is heated.

The common coals used in Indian industry are bituminous and sub-bituminous coal. The gradation of Indian coal based on its calorific value is as follows:

Table 5 Calorific Value of Coal

Grade	Calorific Value Range (in kCal/kg)	Remarks
A	Exceeding 6200	Normally C, D, and E coal grades are imported in Nepal
B	5600 – 6200	
C	4940 – 5600	
D	4200 – 4940	
E	3360 – 4200	
F	2400 – 3360	
G	1300 – 2400	

4.1.1 Physical Properties of Coal

The heating value of coal varies from coal field to coal field. Most of coal imported in Nepal its ranges 4000 to 5000 kcal/kg GCV values analysed.

Proximate Analysis

Proximate analysis indicates the percentage by weight of the Fixed Carbon, Volatiles, Ash, and Moisture Content in coal. The amounts of fixed carbon and volatile combustible matter directly contribute to the heating value of coal. Fixed carbon acts as a main heat generator during burning. High volatile matter content indicates easy ignition of fuel. The ash content is important in the design of the kilns, combustion volume, pollution control equipment and ash handling systems of kilns. A typical proximate analysis of various coals is given in the Table 8.

Table 6 Proximate Analysis of Coals

Parameter	Indian Coal	Indonesian Coal	South African Coal
Moisture	***5.98***	9.43	8.5
Ash	***38.63***	13.99	17
Volatile matter	***20.70***	29.79	23.28
Fixed Carbon	***34.69***	46.79	51.22

Significance of Various Parameters in Proximate Analysis

Fixed carbon:

Fixed carbon is the solid fuel left in the furnace after volatile matter is distilled off. It consists mostly of carbon but also contains some hydrogen, oxygen, sulphur and nitrogen not driven off with the gases. Fixed carbon gives a rough estimate of heating value of coal

Volatile Matter:

Volatile matters are the methane, hydrocarbons, hydrogen and carbon monoxide, and incombustible gases like carbon dioxide and nitrogen found in coal. Thus the volatile matter is an index of the gaseous fuels present. Typical range of volatile matter is 20 to 35%.

Volatile Matter acts as:
- Proportionately increases flame length, and helps in easier ignition of coal.
- Sets minimum limit on the furnace height and volume.
- Influences secondary air requirement and distribution aspects.
- Influences secondary oil support

Ash Content:
Ash is an impurity that will not burn. Typical range is 5 to 40% .Ash reduces handling and burning capacity, Increases handling costs, affects combustion efficiency and boiler efficiency and causes clinkering and slagging.

Moisture Content:
Moisture in coal must be transported, handled and stored. Since it replaces combustible matter, it decreases the heat content per kg of coal. Typical range is 0.5 to 10%. Moisture increases heat loss, due to evaporation and superheating of vapour. It helps, to a limit, in binding fines and also aids radiation heat transfer.

Sulphur Content:
Typical range is 0.5 to 0.8% normally. Sulphur affects clinkering and slagging tendencies. It corrodes chimney and other equipment such as air heaters and economisers and it also limits exit flue gas temperature.

4.1.2 Fuel Analysis

Type of Fuel	Moisture (%)	Ash (%)	Volatile (%)	Fixed Carbon (%)	GCV (Kcal/kg)
Coal					
Assam Coal	0.96-2.99	11.03-26.46	22.84-37.71	37.06-49.88	4864-5603
Chandrapura Coal	3.96-8.36	22.19-37.16	25.07-30.96	33.81-38.49	4077-4867
Indonesian Coal	13.5-16.7	2.82-15.16	42.31-46.29	28.85-35.6	5386-6316
Jharia Coal	0.31-1.48	34.47-46.89	15.83-26.85	33.78-50.06	3520-5034
Raniganj Coal	6.83-8.61	31.3-23.86	25.1-27.41	34.46-42.43	4607-5258
Biomass					
Mustard straw	5.38-9.09	3.1-6.23	70.47-73.79	16.51-17.1	3998-4306
Rice Husk	5.63-19.4	17.4-23.89	48.26-55.95	14.53-14.92	3403-3471
Cotton straw	12.18	3.77	66.75	17.3	4219
Saw Dust	30.61	5.31	53.38	10.7	3235
Internal fuel					
Katni Coal Dust	1.92	45.77	19.66	32.65	3336
Coal Rejects of thermal Power	2.43	68.5	18.09	10.98	2049

Figure 7 Fuel Analysis

4.1.3 Chemical Properties of Coal using in Nepal

The ultimate analysis indicates the various elemental chemical constituents such as Carbon, Hydrogen, Oxygen, Sulphur, etc. It is useful in determining the quantity of air required for combustion and the volume and composition of the combustion gases. This information is required for the calculation of flame temperature and the flue duct design etc. Typical ultimate analyses of various coals are given in the Table 9.

Table 7 Chemical Analysis of Coal

Parameter	***Indian Coal, % (mostly imported in Nepal)***	**Indonesian Coal, %**
Moisture	*5.98*	9.43
Ash	*38.63*	13.99
Carbon	*41.11*	58.96
Hydrogen	*2.76*	4.16
Nitrogen	*1.22*	1.02
Sulphur	*0.41*	0.56
Oxygen	*9.89*	11.88
GCV (Kcal/kg)	4000	5500

Chapter 5: Existing Emission Standards

5.1 Existing Emission Standards of Nepal

The Government of Nepal has promulgated the standards on Chimney Height and Emission for the Brick Kiln Industries on B. S. 13 Falgun 2064 (25 Feb 2008) as given in table 10:

Table 8 Emission Standards and Chimney Height for Brick Kilns

S.N.	Types of Kiln	Suspended Particulate Matter (Maximum Limit)	Height of Chimney (Minimum Limit)
1	Bull's Trench Kiln	600 mg/Nm^3	17 meter
2	Bull's Trench Kiln, Natural Draught (Fixed Chimney)	700 mg/Nm^3	30 meter
3	Vertical Shaft Brick Kiln	400 mg/Nm^3	15 meter

Note:

1. Value of suspended particulate matter shall be calculated considering reference oxygen concentration as 10%
2. Chimney height shall be measured from ground level.

5.2 Proposed Brick Kiln Emission Standards of Nepal

Table 9: Proposed New Brick Kiln Emission Standard

Parameters	Standards
(i) Bull's Trench Kilns (BTK) and Hoffmann Kilns	
Particulate Matter (for natural draft kilns)	500mg/Nm^3
Particulate Matter (for induced draft kilns)	250mg/Nm^3
Stack Height (for natural draft kilns)	30 m
Stack Height (for induced draft kilns)	17 m
Notes: 1. Emission sample shall represent both charging and non-charging conditions 2. Particulate Matter (PM) results to be normalized at 4% CO2 as below PM (normalized) = PM (Measured x 4%/measured CO2% 3. These emission standards shall be met by good fuel charging and operating practices/installing gravity setting chamber.	
(ii) Vertical Shaft Kilns (VSK)	
Particulate Matter (Sum of one Shaft)	250 mg/Nm3
Stack Height	15 m
(iii) Hybrid Hoffmann Kiln (HHK)	
Particulate Matter	200 mg/Nm3
Stack Height	7 m
(iv) Tunnel Kiln	
Particulate Matter	100 mg/Nm3
Stack Height	10 m
Note:	

The above standards shall be applicable for different kilns if coal, firewood and/or agricultural residues are used as fuel.

The present practice of fixing emission standards depending uponthe kiln technology must not be continued for long because there is a huge difference in emissions from different types of brick kilns. There should be only one standard regardless of the kind of technology. But this cannot be changed abruptly. Although new technologies with much lower emissions are available in the neighboring countries and slowly some owners have started to install such new technologies, . brick kiln owners may need some time (may be up to five years), to replace the existing inefficient technology with modern ones. In the promulgated standards, it must be specifically mentioned that the promulgated standards will be revised to make them more stringent in the years to come. The owners should be conveyed that they have to keep on improving the technology and operating practices and should also be ready to adopt more efficient technologies and operating practices.

Figure 8: Improved Brick Kiln Chimney in Valley

Chapter 6: Previous Study of Brick Kiln Emissions in Nepal

Brick Stack Emission monitoring were done in several different years. Ministry of Population and Environment (MoPE), Department of Environment (DoEnv) and few other organizations have published those monitoring data.

6.1 Previous Stack Monitoring Result (Secondary Data)

6.1.1 Stack Emission Monitoring Report of 2005

Institute of Environmental Management (IEM), ESPS/DANIDA conducted study in 2005 when BTK Induced Draughttechnology was first introduced in Nepal. The datapresented as given in table 10:

Table 10 SPM in Brick Stack Emission 2005

SN	Brick Kiln	SPM, mg/Nm^3	Average SPM, mg/Nm^3 Technology Wise
1.	BTK (Induced)	478	478
2.	BTK (Natural)	588	667
3.	BTK (Natural)	679	
4.	BTK (Natural)	667	
5.	BTK (Natural)	733	
6.	VSBK	330	315
7.	VSBK	299	

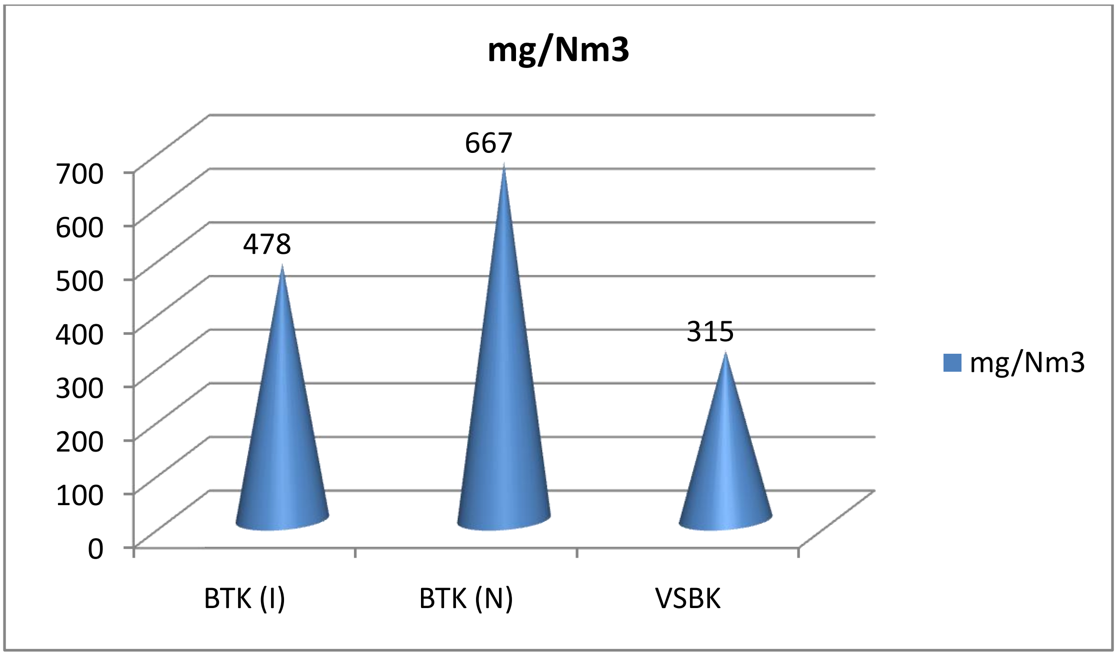

Figure 9: SPM Concentration in 2005

6.1.2 Stack Emission Monitoring Report of 2009

The findings of Brick Stack Monitoring , 2009 of Ministry of Population and Environment the result are given in table11

Table 11 SPM in Brick Stack Emission 2009

S.N.	Brick Kiln	SPM, mg/Nm^3	Average SPM, mg/Nm^3 Technology Wise
1	BTK (Induced)	707	573
2	BTK (Induced)	295	
8	BTK (Induced)	716	
3	BTK (Natural)	609	749
4	BTK (Natural)	724	
5	BTK (Natural)	757	
6	BTK (Natural)	812	
7	BTK (Natural)	727	
9	BTK (Natural)	732	
10	BTK (Natural)	881	
11	VSBK	364	362
12	VSBK	383	
13	VSBK	340	

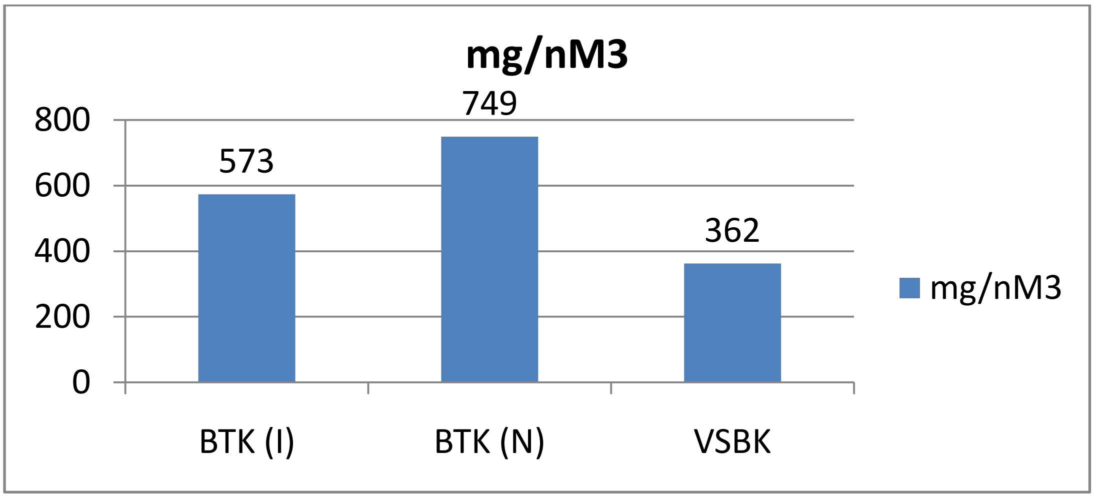

Figure 10SPM Concentration in 2009

6.1.3 Stack Emission Monitoring Report of 2010

The findings of Brick Stack Monitoring report, 2010 of Ministry of Population and Environment the result are given in table 12:

Table 12 Stack Emission Monitoring Report of 2010

S.N.	Brick Kiln	SPM, mg/Nm^3	Average SPM, mg/Nm^3 Technology Wise
1	BTK (Induced)	380	400
2	BTK (Induced)	420	

S.N.	Brick Kiln	SPM, mg/Nm^3	Average SPM, mg/Nm^3 Technology Wise
3	BTK (Natural)	680	693
4	BTK (Natural)	630	
5	BTK (Natural)	768	
6	VSBK	179	258
7	VSBK	336	

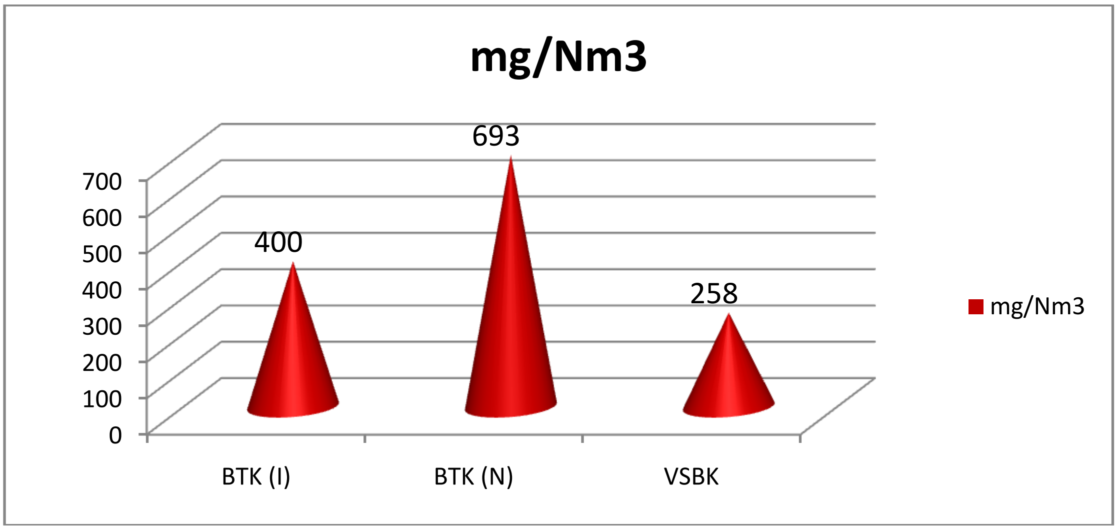

Figure 11SPM Concentration in 2010

6.1.4 Stack Emission Monitoring Report of 2011

The findings of Brick Stack Monitoring report, 2011 of Ministry of Population and Environment the result are given in table 13:

Table 13 Stack Emission Monitoring Report of 2011

S. N.	Brick Kiln	SPM, mg/Nm^3	Average SPM, mg/Nm^3 Technology Wise
1.	BTK (Induced)	437	414
2.	BTK (Induced)	335	
3.	BTK (Induced)	455	
4.	BTK (Induced)	428	
5.	BTK (Movable)	913	970
6.	BTK (Movable)	1003	
7.	BTK (Movable)	995	
8.	BTK (Natural)	497	554
9.	BTK (Natural)	360	
10.	BTK (Natural)	358	
11.	BTK (Natural)	479	
12.	BTK (Natural)	483	
13.	BTK (Natural)	545	
14.	BTK (Natural)	627	
15.	BTK (Natural)	421	

S. N.	Brick Kiln	SPM, mg/Nm^3	Average SPM, mg/Nm^3 Technology Wise
16.	BTK (Natural)	532	
17.	BTK (Natural)	896	
18.	BTK (Natural)	620	
19.	BTK (Natural)	437	
20.	BTK (Natural)	388	
21.	VSBK	129	181
22.	VSBK	191	
23.	VSBK	195	
24.	VSBK	209	

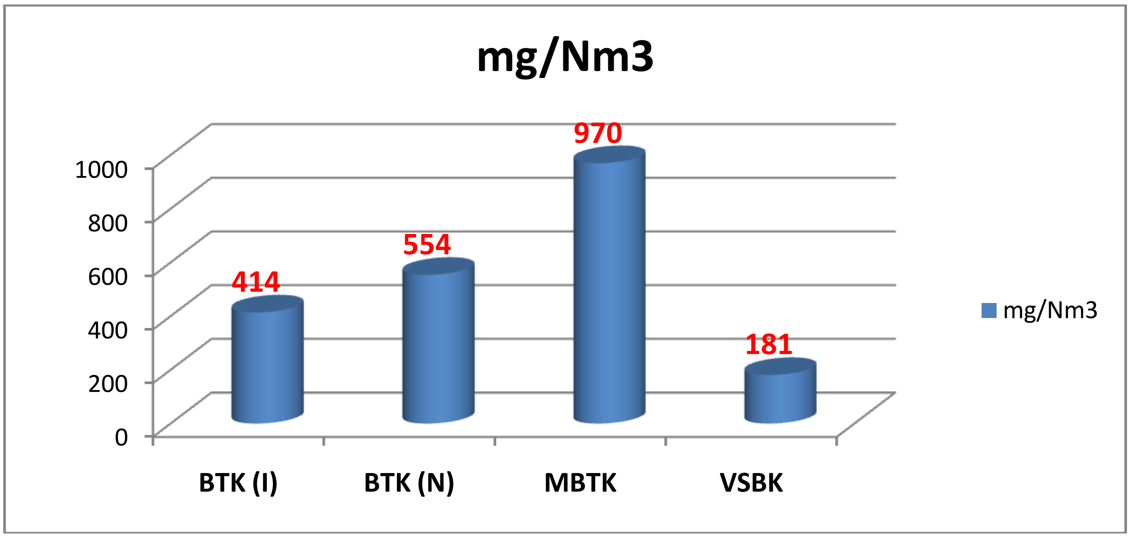

Figure 12: Average SPM Concentration in 2011

6.1.5 Stack Emission Monitoring Report of 2016

The findings of Brick Stack Monitoring report, 2016 of Ministry of Population and Environment the result are given in table14. 12 brick kilns (10 BTK, Induced draft, one Hoffmann, one HHK one VSBK) were monitored during this study:

Table 14 SPM Concentration in Brick Emission in 2016

S. N.	Brick Kiln	Location	SPM, mg/Nm^3	Average SPM, mg/Nm^3	Remarks
1.	BTK (Induced)	Lalitpur	284	267	
2.	BTK (Induced)	Lalitpur	103		MiNERGY/ICIMOD
3.	BTK (Induced)	Lalitpur	414		MiNERGY /ICIMOD
4.	BTK (Induced)	Kathmandu	400	398	
5.	BTK (Induced)	Kathmandu	396		
6.	BTK (Induced)	Bhaktapur	321	370	
7.	BTK (Induced)	Bhaktapur	380		
8.	BTK (Induced)	Bhaktapur	338		
9.	BTK (Induced)	Bhaktapur	441		

S. N.	Brick Kiln	Location	SPM, mg/Nm³	Average SPM, mg/Nm³	Remarks
10.	HHK	Lalitpur	246	246	
11.	Hoffmann	Lalitpur	390	390	
12.	VSBK	Lalitpur	147	147	

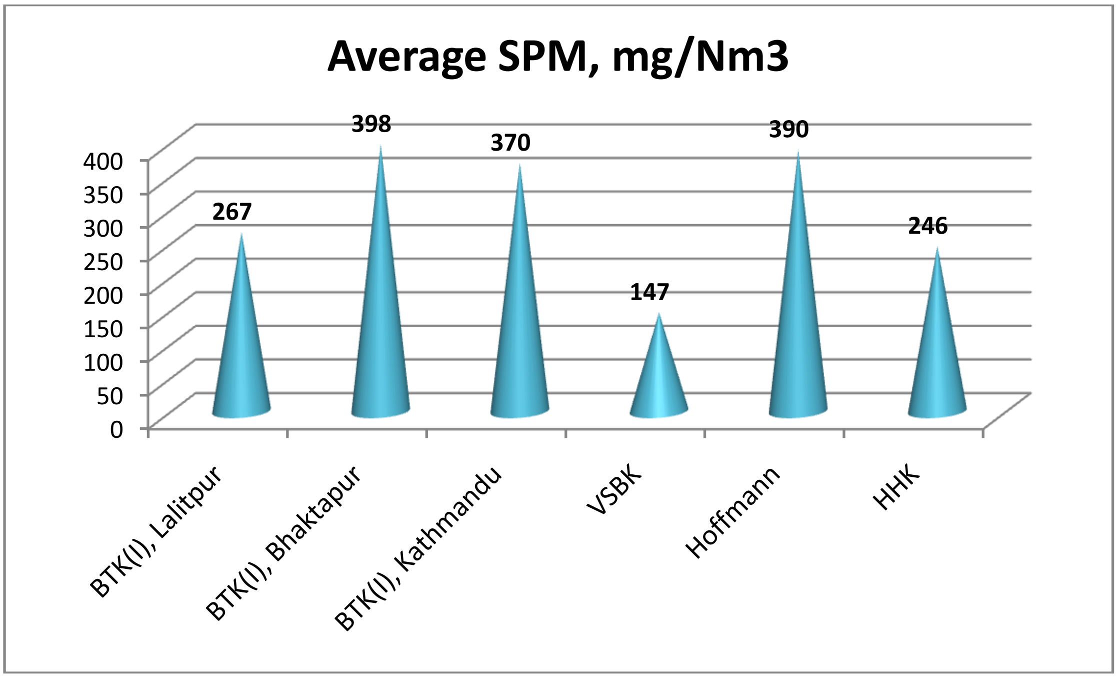

Figure 13: Average SPM Concentration in Brick Kilns in 2016

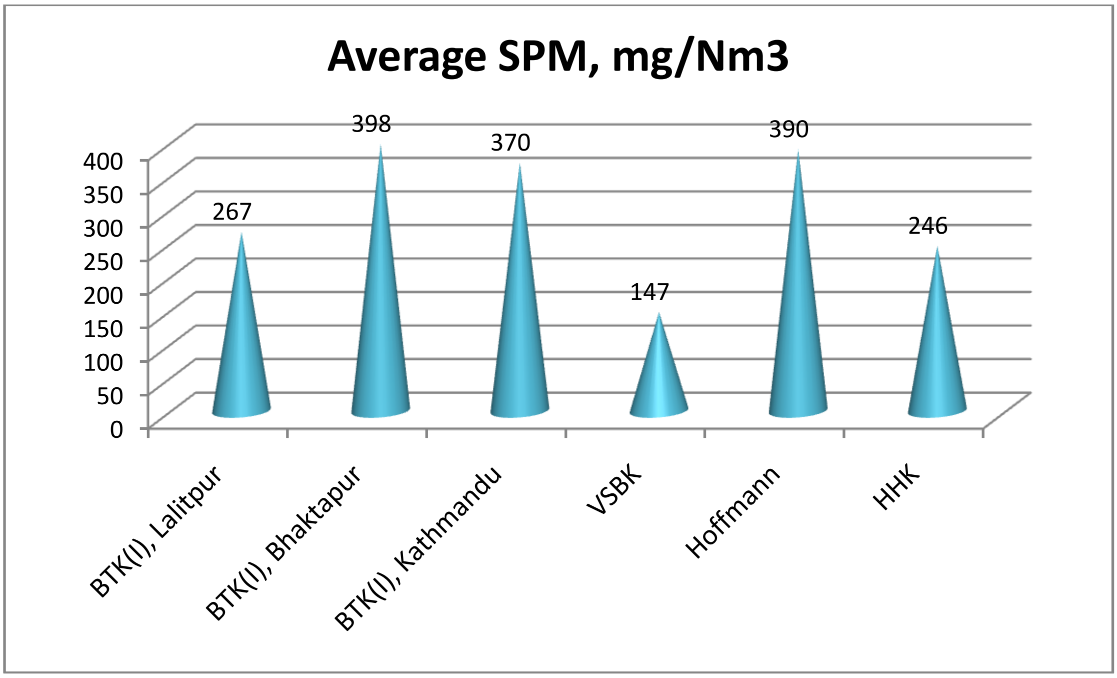

Figure 14: Average SPM Concentration in Brick Kilns (2016)

6.2 Comparison of Results

Stack emission monitoring was done by different organizationsfor the pastmany years. The available primary and secondary data have been compared here to show the trend of SPM before and after thepromulgationof the national standards in 2008 by MoPE.

Table 15 Comparison of SPM Concentration in Different Years

Brick Kilns	Average SPM concentration, mg/m^3				
	2005	**2009**	**2010**	**2011**	**2016**
BTK (Induced)	478	573	400	414	345
BTK (Natural)	667	749	693	554	-
VSBK	315	362	258	181	147
Hoffmann	-	-	-	-	390
HHK	-	-	-	-	246

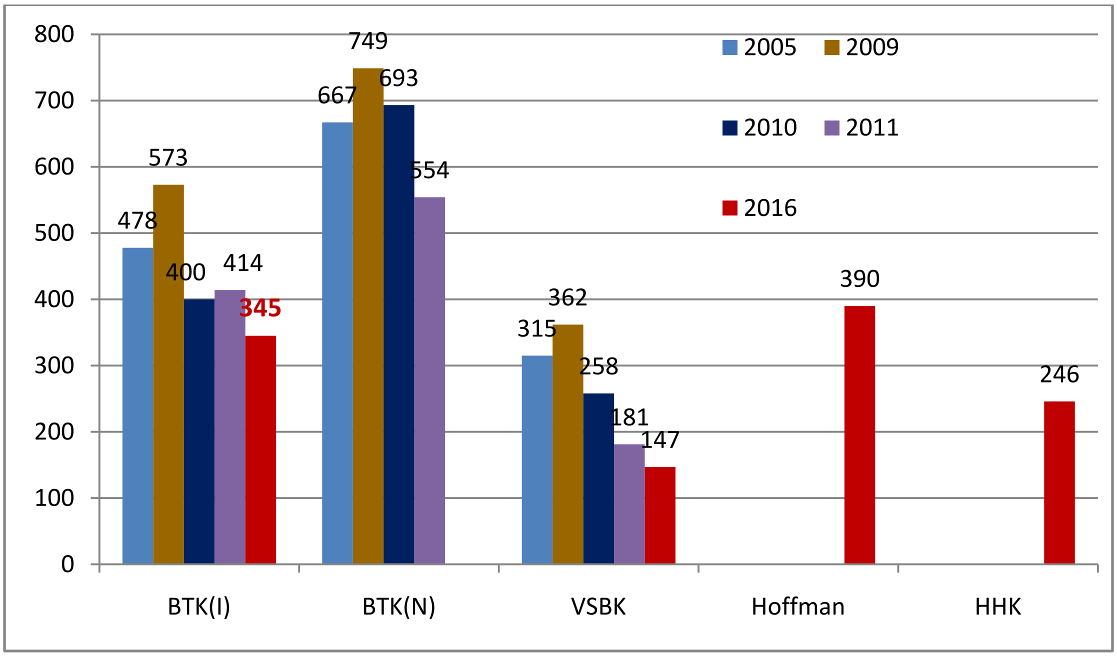

Figure 15 Comparison of SPM Concentration in Different Years

Chapter 7: Observations and Findings in Selected 30 Brick Kilns

During the current study,thirtybrick kilns out of 110 brick kilns (Kathmandu- 15, Lalitpur – 32 and Bhaktapur – 63)in Kathmandu, Lalitpur and Bhaktapur Districtswere selected on which. stack emission monitoring was done. These 30 kilns included 5 from Kathmandu District, 9 from Lalitpur district and 16 from Bhaktapur district. Among these BTK (Induced) were dominant. Most of the BTK are (Induced), and were converted from the original BTK (Natural). BTK (Induced) is considered more energy efficient and less polluting technology than the BTK (N).

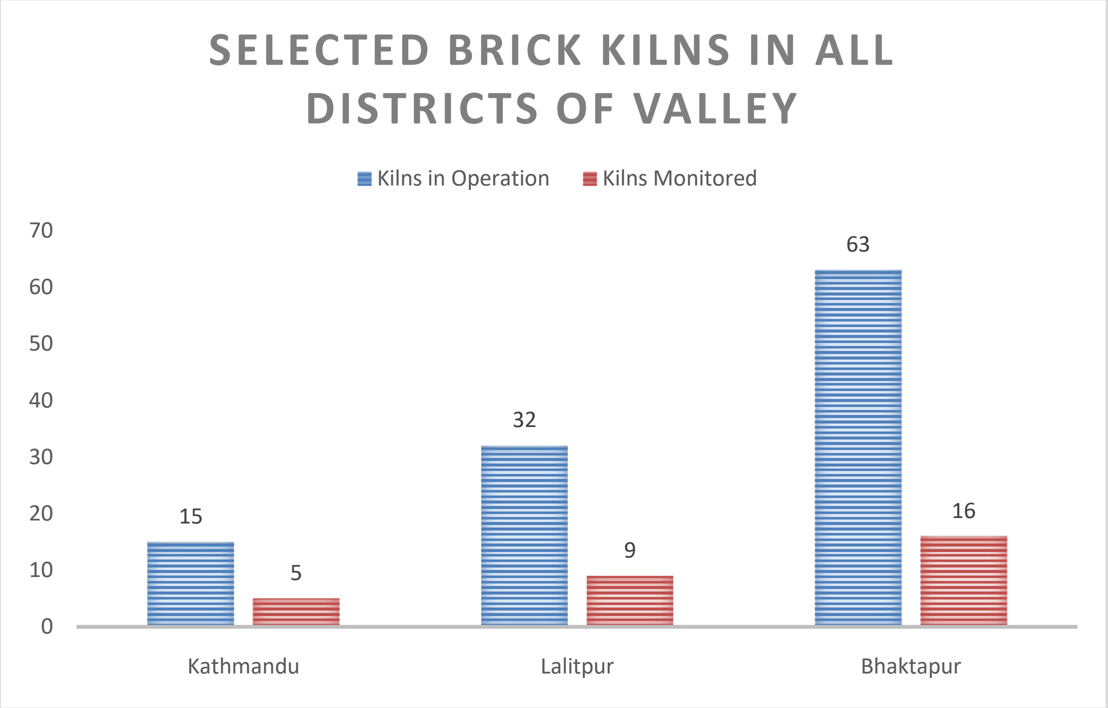

Figure 16: Brick Kilns in Valley

7.1 Observations

During the visit of kilns walkthrough were done in the entire process, technology and operating practices. Fixed questionnaire filled in the all visited kilns to gather general and technological information. We found that most of the brick kilns did not have any recorded information or data. Verbal information from the management personnel and technical employees were considered to draw information. Chimney height was measured with help of clinometers. Any kind of Pollution control devices was not seen to be installed by any brick kilns except one kiln where, gravity settling chamber and water spraying was found to be installed.

In most of the brick kilns skilled, technical, high paid and trained employees were not found. Mostly unskilled workers were available. Brick making is a fully technical control based technology, negligence or use of unskilled workers would result in production of low quality bricks and high fuel (inefficient) consumption and higher SPM generation. Besides the stack emission, dust generation during the different work and blown due to air movement were seen as major issues to the employees and neighbour residence. Wind breaker or shades were not seen in any brick kilns.

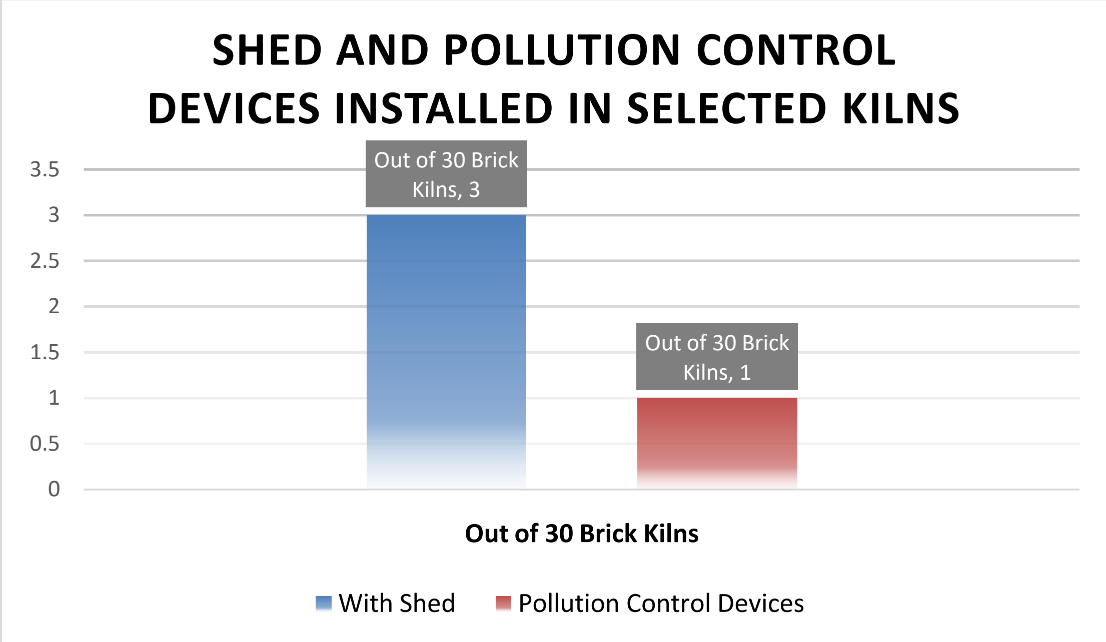

Figure 17: Pollution Control Devices

7.2 Other Observations of Brick Kilns

The general observations for the visited brick kilnswere:

- Heat losses were seen in many places due to lack of proper insulation on top and side of the kilns.
- Black smokes were seen in the chimney emission in most industries during coal charging.
- Maximum numbers of brick industries were Fixed Chimney Bulls Trench Kiln (FBTK) with Induced draught technology.
- Only twoHoffman's Kiln and two (?)Vertical Shaft Brick Kiln (VSBK) were seen in Kathmandu Valley.
- Insulation level was not adequate in any of the kilns. (With better insulation coal consumption can reduced).
- Only a few kilns were having sampling point, platform and ladder in chimney although legally it is mandatory for all.
- Management were seen be aware about environmental issues of brick kilns but were not willing to improve.
- The major energy use on brick industries was from coal and isimported mainly from India.
- Most of the induced draught brick kilns have installed DG set of moderate size as back up to run the machines during load shedding.
- The average productions of visited kilns were 4.8 million bricks per year.
- There was no significant disturbance in production by load shedding in brick industries.
- Insulations on the top (inadequate RAPISH thickness) and at the doors (inadequate mud plaster at DWARI) were not adequate.
- Coal feeding practices need improvement in some of the kilns.
- In general, the brick industry premises were hot workplace and the dust emission in and around industry area is high.

7.3 Technology details of visited Brick Kilns

Most of the kilns seen in Kathmandu Valley were operated with BTK (Induced draft) technology. Only a few of the VSBK, and Hoffmann were operating in the valley. Visited brick kilns were registered in Department of Cottage and Small Scale Industries. All the kilns were registered after FY 2047/48. Among the 30 brick kilns 1 VSBK, 1 Hoffmann and 28 BTK (Induced Draft) technology adopted. Most of the BTK brick kilns have adopted Zig-Zag setting pattern for green brick stacking to kiln. This helps to reduce the SPM concentration and fuel consumption. Most of the brick kilns have adopted single man small spoon continuous fuel feeding practice . Details are given in an annex: 2.

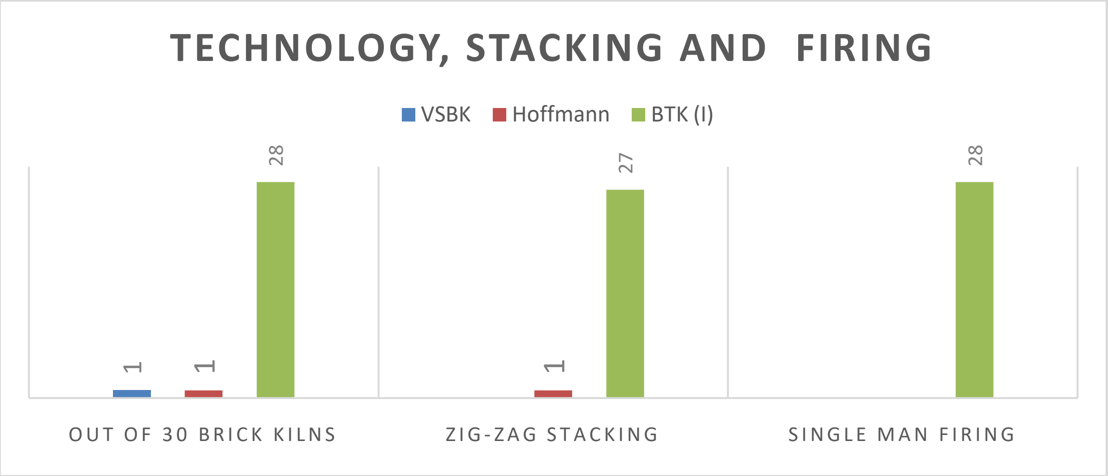

Figure 18: Technology, Stacking and Firing

7.4 Production and Fuel consumption in Visited Brick Kilns

Most of the kilns were using coal as the main fuel, only a minor percentage use locally available fuel. A total of 9334 workers are working in this industry, this includes 2772 female workers. The visited 30 kilns have 1691 lakhs capacity to produce brick per year but actually produced in last FY was 1449 lakhs i.e. 86% of the capacity. These industries are using coal as a main fuel and consume 12,409 tons of coal and 1881 tons of other local fuels. For details see annex 3.

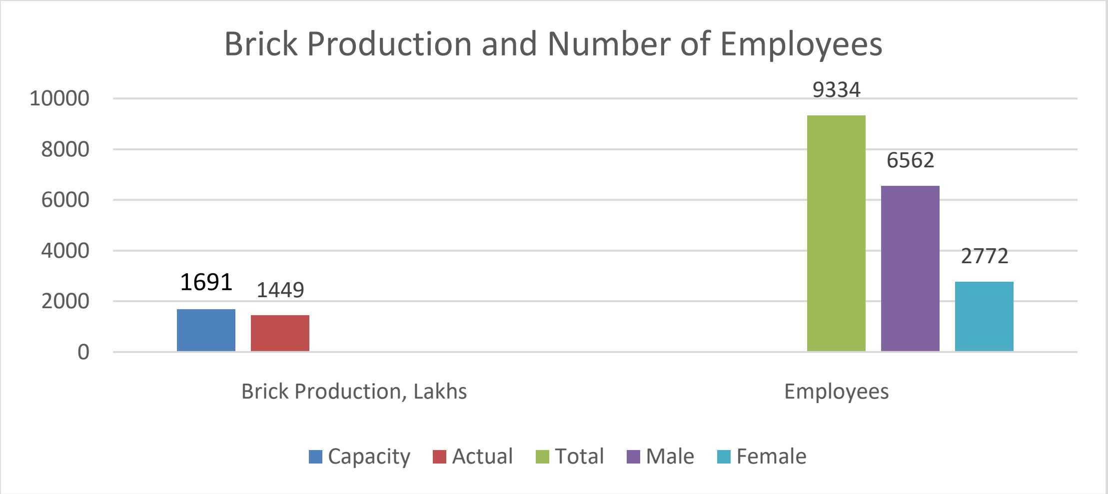

Figure 19: Brick Production and Employees Involve

7.5 Current Stack Monitoring Result (Primary Data)

During this study 30 brick kilns were monitored to generate the primary data of stack emission. Most of the kilns seen in Kathmandu Valley operated with BTK (Induced draft) technology. Only a few VSBK and Hoffmann kilns are operating in the valley. Thee obtained data of SPM values are presented in table: 16

Table 16: SPM and Height of Chimney in Visited Brick Kilns

S.N.	Name of Industry	Height of Chimney (Mtr)	SPM, mg/Nm3	Standards, mg/Nm3	Proposed Standards, mg/m3
1	Kathmandu 1	18.23	229.19	600	250
2	Kathmandu 2	28.96	426.65		
3	Kathmandu 3	28.96	325.31		
4	Kathmandu 4	22.86	426.65		
5	Kathmandu 5	22.86	376.30		
6	Lalitpur 1	17	168.28	600	250
7	Lalitpur 2	14	143.64	400	250
8	Lalitpur 3	20.42	290.25	600	250
9	Lalitpur 4	No Chimney	250.31	-	200
10	Lalitpur 5	17.37	437.29	600	250
11	Lalitpur 6	28.96	159.92		
12	Lalitpur 7	26.52	401.87		
13	Lalitpur 8	19.2	375.39		
14	Lalitpur 9	22.86	368.33		
15	Bhaktapur 1	22.86	137.94	600	250
16	Bhaktapur 2	28.356	349.07		
17	Bhaktapur 3	32.01	397.34		
18	Bhaktapur 4	24.39	399.91		
19	Bhaktapur 5	18.29	413.75		
20	Bhaktapur 6	28.96	375.76		
21	Bhaktapur 7	21.34	351.02		
22	Bhaktapur 8	28.96	220.54		
23	Bhaktapur 9	17.98	418.93		
24	Bhaktapur 10	29.57	369.36		

S.N.	Name of Industry	Height of Chimney (Mtr)	SPM, mg/Nm3	Standards, mg/Nm3	Proposed Standards, mg/m3
25	Bhaktapur 11	25.91	324.48		
26	Bhaktapur 12	70	374.93	600	250
27	Bhaktapur 13	22.86	285.49		
28	Bhaktapur 14	27.74	315.16		
29	Bhaktapur 15	22.86	279.89		
30	Bhaktapur 16	17.37	274.56		

Average SPM Concentration of different technologies and comparison with existing and proposed standards and comparison with the standards is presented in Table 17..

Table 17: Comparison with Standards

Name of Industry	Average SPM, mg/Nm3	Standards, mg/Nm3	Proposed Standards, mg/m3
BTK (Induced)	326	600	250
VSBK	144	400	250
Hoffman	374	-	250

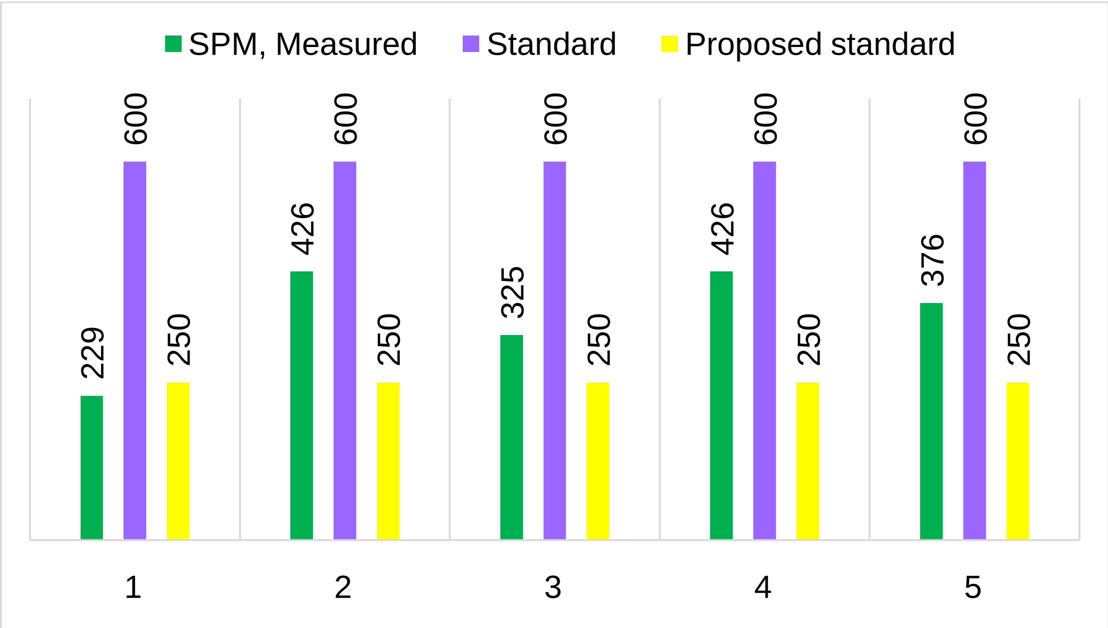

Figure 20 SPM Concentration and Standard Comparison in Brick Kilns of Kathmandu District

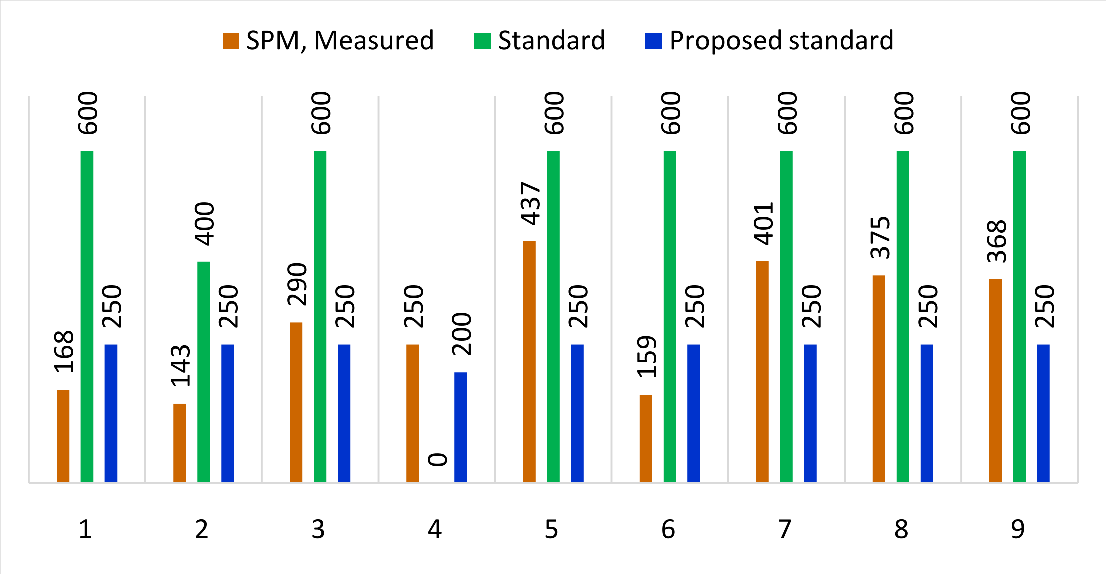

Figure 21 SPM Concentration and Comparision with Standards in Brick Kilns of Lalitpur District

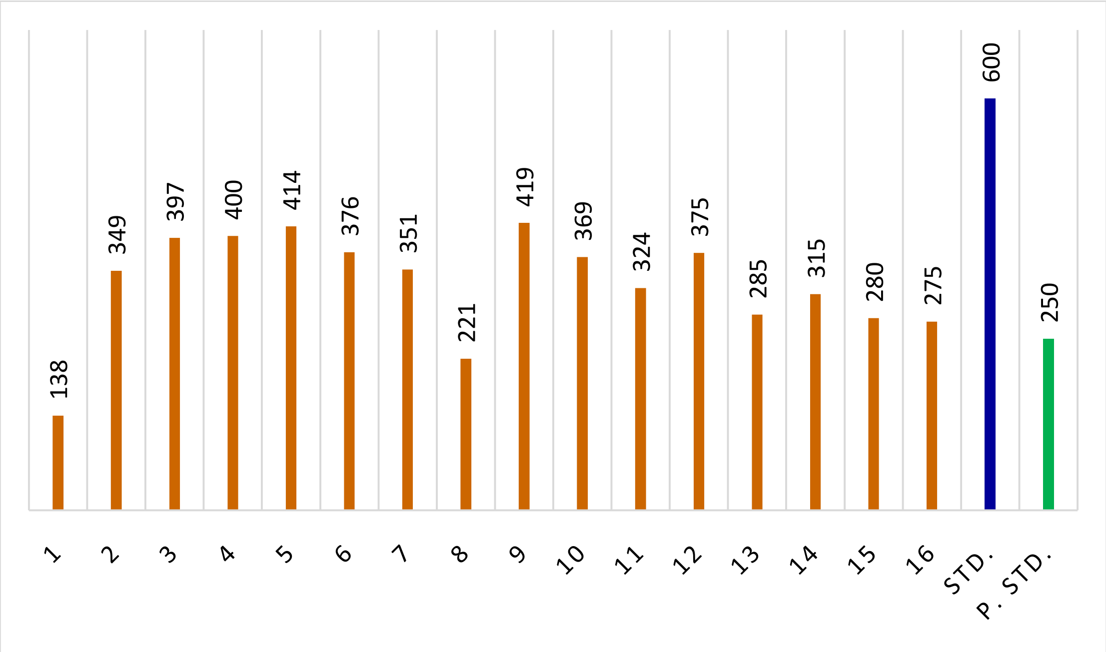

Figure 22 SPM Concentration and Comparison with Standards in Brick Kiln of Bhaktapur District

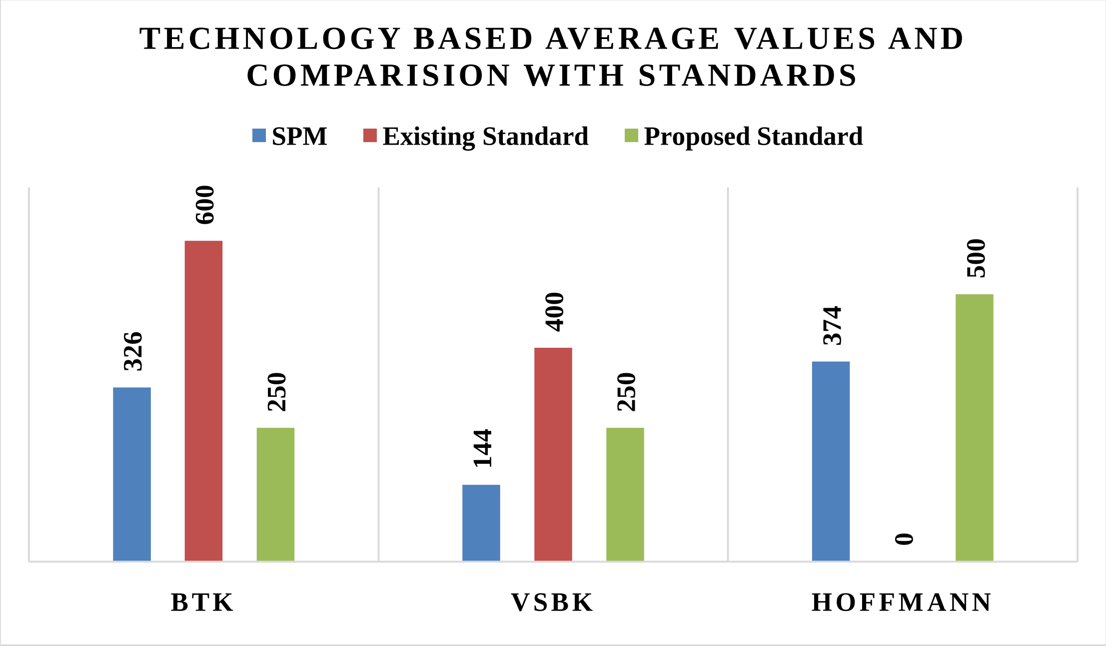

Figure 23: Average Concentration and Comparison with Standards

Discussion

SPM Concentration of all technology of brick kilns were found well below the existing standards. Brick kiln industries have improved their operating practices compared to the previous years. Most of the BTK (Induced) technologies were using zigzag setting pattern for green brick setting. Some of the kilns have installed gravity settling chamber.One haswater spraying system. Although valley kilns meet the national standards, black smoke was also seen in the chimney during coal firing. Lots of opportunities and technologies are available that can reduce the SPM concentration well below the above values. Ministry of Population and Environment is working for the publication of new standards for brick kiln emission. The Average SPM concentration of BTK is326 mg/Nm3; that for VSBK was 144 mg/Nm3 and for Hoffmann was 374 mg/Nm3. These valuesshow that all the operating kilns are within the current standards. However, they cannot meet the new proposed standards.

Most of the kilns do not have any kind of shade to protect the workers from direct sunlight. Wind breaking wall do not exist in any brick kilns, so dust c blown from the kilns were seen in very highup to 3 kilo meters from the kiln.

Except for a few, none of the kilns have adopted any kind of pollution control devices or practices to control SPM and Sulphur oxide concentration such as Gravity Settling Chamber, Water Spraying, using of coal as an internal fuel and use of stack flue gas heat in drying chamber.

Chapter 8: Sustainability of Brick Sector in Valley

Nepalese brick sector is characterized by outdated technologies with low energy efficiency and high emissions, low mechanization rate, dominance of small-scale brick industries with limited financial capacity, and dominance of single raw material (clay) and production of solid clay brick.

The current status of brick kilns can't be sustainable. Nepal has every reason to upgrade its brick sector in order to save valuable natural resources, reduce air pollution, and increase energy efficiency. The government has already established directives that ban the use of MBTK and discourage to use of firewood. FBTKs owners of the country are also eagerly waiting for new technology for adoptation.

For the protection of environment, it is necessary to use internal fuels and industrial waste, such as gangue and fly ash in brick production. Instead of coal, biomass, agriculture residue and un-burnt rice husk ash can be used as internal fuel; these internal fuels will reduce SPM level significantly.

Brick Kilns needs to diversify their products and produce bricks with high porosity, such as, bricks with multi holes or hollow brick. Most of brick kilns use coal as the fuel. Internal fuel is not used by Nepalese brick kilns. In many countrys, internal fuel are used in highly efficient kiln technology, the HHK has a unique technique of forming green bricks: granulated coal is injected for internal combustion. This approach results in lower energy usage, higher quality bricks and reduced pollution. Bricks of any size, shape and pigmentation can be produced at the plant with minor modifications. All bricks will be of uniform quality and will meet international standards for strength, quality and appearance. The Hoffman kiln has high working efficiency, large production capacity, saving materials and requiring only a medium investment at present.

The development of the brick industry in Valley should aim at:

- (i) Moving from traditional brick-making technologies (e.g. FBTK) to cleaner ones (e.g. High Draught zigzag kiln, Tunnel and HHK);
- (ii) Diversifying products (e.g. hollow and perforated bricks) and finding alternative raw materials that are locally available;
- (iii) Increasing the proportion of large-scale enterprises with higher capacity to adapt to cleaner technologies.

To achieve anenergy efficient, less polluting and sustainable brick kiln following recommendations should be implement.

1. Country should move from traditional brick-making technology (i.e. FBTK) to cleaner ones by stopping (prohibition, banning) of the new registration of FBTK.
2. Develop awareness and disseminate to stakeholders (e.g. brick owners, workers and the financial sector) the benefits of adopting cleaner Brick kiln Technologies.
3. The government and FNBI should jointly establish a Brick Technology Center to raise awareness on the benefits of cleaner technologies.

The centre should:

- o disseminate information on the social benefits provided by cleaner technologies, new wall materials (e.g. perforated and hollow bricks) and alternative raw materials;
- o promote pilot projects of new technologies with improved provisions (e.g., mechanized, higher labour productivity and larger product lines);
- o improve use of existing dissemination channels (e.g., field visits to pilot plants, video demonstrations of the technologies etc.) and
- o introduce new channels (e.g., newsletters, industry journals, conferences, and Internet blogs).

4. Government and donor agencies should assist the entrepreneurs in getting access to carbon markets for carbon emission reductions provided by cleaner technologies.
5. Introduce regulations and policies that encourage/promote adoption of cleaner technologies like HHK and Tunnel Kiln
6. Develop a separate zone as Brick Clusters to accommodate a large number of Brick Kilns. The cluster shall have the facilities of basic infrastructure for all kilns (e.g. roads, electricity, and water) and other facilities (e.g. schools for the employees' children, health care centres).
7. Improve working conditions by reducing hazardous work manually and eliminate child labor and child living with parents in the factory premises.
8. Recognize brick kilns as one of the main industrial sector and facilitate them to enable easier access to financial resources.
9. Government should revise emission standards and reduce the existing permissible level aiming at reduction of environmental pollution.
10. Facilitate the availability of subsidized credit lines to account for reduced health impacts from pollution and of other economic incentives supporting the production of new wall materials and use of alternative raw.

Chapter 9: Conclusionand Recommendation

9.1 Conclusion

Three Brick Kiln technologies i.e. FBTK, VSBK and Hoffman are in operation in Kathmandu Valley. The FBTK is the mostdominant technology being used(97 percent of all the kilns). FBTK is comparatively more polluting and relatively inefficient in terms of energy efficiency. Hoffmann kilns and the VSBKs are substantially cleaner, but represent just a very few percent of the total kilnscurrently in operation.

Most of the monitored brick kilns show that SPM concentrations were below than the existing promulgated standard. But these kilns are not in level of proposed standards(standard in preparation?) and also not in level of existing brick kiln technology emerged in the world. The emission level is much higher than the existing standards of India and China.

9.2 Recommendation for Reduction of SPM Level

We like to recommendthat the new standards being prepared by the MOPE is finalized soon and promulgated as soon as possible. The following recommendation need to be followed to help the brick kiln to comply with the new emission standard.

Government should:

- Immediate promulgation of proposed brick kiln emission standards.
- Standard on coal with high calorific value, lowest feasible sulfur content, and low ash content to be made and enforced.
- Encourage to introduce a large-scale brick producing kilns with cleaner technologies.
- No new registration of BTK brick kiln industries inside the Kathmandu Valley
- Effective policies and regulations need to be develop and practice for mandatorily adoption of energy efficient and less polluting technologies like Zig Zag Kiln, Tunnel Kiln, and HHK.
- Strict supervision and monitoring of Compliance of Brick Kiln Emission Standards.
- Encouragement of resource efficient products like hollow and perforated bricks, and limiting the production of solid bricks in phase wise.

Brick Kilns Should:

- Adaptation of cleaner technology and large scale brick kiln.
- Compulsorily use of 40 % coal as an internal fuel.
- The brick industries in operation must have sampling port, platform and ladder by the end of 2006.
- Brick industries made responsible to submit their emission status to DOI and DOCSI with the help of accredited laboratories once a year.
- Use alternative locally available low Sulphur containing fuel instead of imported coal.
- Adoption of improved feeding, firing and operating practices in existing FCBTKs.
- Retrofitting of existing FBTK kiln and convert into High Draft Kiln with zig zag firing.
- Installation of temperature indicator in firing zone, flue duct and chimney which helps to monitor and control the combustion process.

- Use double walled insulated feedhole covers to prevent heat loss from fuel charging holes.
- Prepare double walled wicket and between the walls filled with ash it helps to control the leakage and heat loss.
- In FBTK top insulation should be minimum 7-inch-thick which provide heat insulation.

Fugitive Dust Emission Control

Besides SPM emission from flue gas,fugitive dust generations were also core issues in the kilns. The following recommendation will help to control the generation of fugitive dust in brick kilns:

- Crushing of coal should be done in an enclosed equipment/ area to avoid process emissions.
- Raising a 2 feet wind breaker wall along the outer trench wall of FBTK.
- Covering of the top ash layer in the preheating zone with sheet in FBTK.
- Introduction of Insulated Blanket instead of Rapish for Insulation of top of the kiln.
- The approach road and the road around brick kiln should be paved/stabilized.
- Water should be sprinkled frequently over roads around brick kiln and over the ash layer before its removal and transfer.
- Two or three rows of trees should be planted along the outer periphery of kiln area.

Some Other Recommendations for Brick kilns to compliance of New Proposed Standards

All the Brick kilns of Kathmandu Valley install appropriate Pollution Control System from following:

- Gravity Settling Chamber
- Internal Fuel use
- Drying Chamber
- Water Spray in Chimney

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Annex 1: General Information of Visited Brick Kilns

Annex 2: Technology Adapted in Visited Brick Kilns

Annex 3: Lab Report of obtained value of SPM and Height of Visited Kilns

Annex 4: Observation Checklist

Annex 5: Suggestion and feedback Provided by Federation of Nepalese Brick Industries (FNBI)