Stack Monitoring Report of Vertical Shaft Brick Kilns (VSBK)

Jhapa, Morang and Lalitpur - NEPAL

Prepared for:

VSBK Project (Nepal)

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List of Abbreviations and Acronyms

BTK	Bull's Trench Kiln
CPCB	Central Pollution Control Board (India)
DA	Development Alternatives (India)
De	Equivalence diameter
FC BTK(s)	Fixed Chimney Bull's Trench Kiln (s)
Kg	Kilogram
MC BTK(s)	Moving Chimney Bulls' Trench Kiln (s)
MOICS	Ministry of Industry, Commerce & Supplies
MOPE	Ministry of Population & Environment
SDC	Swiss Agency for Development and Cooperation
SKAT	Swiss Center for Development Cooperation in Technology and Management
TERI	The Energy & Research Institute (India)
VSBK(s)	Vertical Shaft Brick Kiln (s)

Executive summary

"Vertical Shaft Brick Kilns (VSBK)" of Chinese origin has been introduced to Nepal by the Swiss Agency for Development and Cooperation (SDC) – through their programme in Nepal: "**VSBK Project (Nepal)".** A total of six units of VSBK kilns are now operating in five districts of Nepal: Jhapa (1), Morang (2), Lalitpur (2) and Bhaktapur (1).

The characteristics feature of VSBK technology is low emission levels of pollutants. VSBK programme (Nepal) has given an opportunity to monitor the stack emission to Soil Test Pvt. Ltd.(hereafter called Soil Test) - a private sector laboratory having facility to monitor and analyze the different parameters of air, stack, water, soil and food.

Accordingly, Soil Test conducted the measurement of the velocity and pollution concentration of the flue gases from the chimneys of VSBK shaft using Envirotech stack velocity monitor and stack sampler. As the velocity was very low, differential manometer was used to determine it. The following are the essentials of our findings.

Concentration of Suspended Particulate Matters (SPM)

The obtained average concentration of SPM compared to the Nepal (proposed) and Indian standards are as given in the table: (The values are calculated on the basis of normal conditions).

SN	Location	Average Concentration mg/Nm^3	Proposed Nepal Standard mg/Nm^3	Indian Standard mg/Nm^3
1.	Jhapa	222	450	250
2.	Morang	270		
3.	Lalitpur	141		

Remarks: The obtained average concentrations of SPM in all the kilns are substantially lower than the proposed national standard. The concentrations in the kilns installed in Jhapa and Lalitpur are also lower than the Indian Standard as well, whereas those in the kilns in Morang are slightly higher.

Avi and Sabi VSBK, Morang

The industry has two shafts but only one shaft was in operation, so monitoring was done in the both chimneys of shaft 1. The following values were obtained under normal condition:

S.N.	Location	Stack Temp ^oC	Velocity, m/s	SPM, mg/Nm^3
1	Shaft 1 West Stack	80	2.27	300.21
2	Shaft 1 East Stack	65	2.22	276.89

Note: Brick size: L: 250mm; B: 120mm; H: 78mm

Shaft Size: 1865 X 1070 mm

Su-Sweta VSBK, Morang

The industry has two shafts, both of which were in operation. Stack emission monitoring was done in all the four chimneys. The following values were obtained under normal condition:

S.N.	Location	Stack Temp ^oC	Velocity, m/s	SPM, mg/Nm^3
1	Shaft 1 West Stack	94	2.42	254.42
2	Shaft 1 East Stack	105	2.34	222.69
3	Shaft 2 West Stack	55	2.18	295.59
4	Shaft 2 East Stack	86	2.40	274.66

Note: Brick size: L: 250mm; B: 120mm; H: 72mm

Shaft Size: 1865 X 1070 mm

Jhapa VSBK, Jhapa

The industry has two shafts, both of which were in operation. Stack emission monitoring was done in all the chimneys. The following values were obtained under normal condition:

S.N.	Location	Stack Temp ^oC	Velocity m/s	SPM, mg/Nm^3
1	Shaft 1 West Stack	61	2.20	208.03
2	Shaft 1 East Stack	60	2.20	235.65
3	Shaft 2 West Stack	60	2.20	218.78
4	Shaft 2 East Stack	58	2.19	229.41

Note: Brick size: L: 230mm; B: 110mm; H: 70mm

Shaft Size: 990 X 1960 mm

Satya Narayan VSBK, Lalitpur

A total of 6 shafts are installed in the factory. As per request of VSBK-Program stack monitoring were done in shafts numbers 4 and 6 only. The values obtained under normal condition are as follows:

S.N.	Location	Stack Tem ^oC	Velocity, m/s	SPM, mg/Nm^3
1	Shaft 4 South Stack	47	2.16	160.56
2	Shaft 4 North Stack	58	2.19	159.08
3	Shaft 6 South Stack	48	2.65	131.95

S.N.	Location	Stack Tem ^oC	Velocity, m/s	SPM, mg/Nm^3
4	Shaft 6 North Stack	47	2.64	114.25

Note: Brick size: L: 230mm; B: 110mm; H: 55mm

Shaft Size: Shaft # 4: 960 X 1920 mm

Shaft # 6: 1200 X 1920 mm

Conclusion:

- It is seen that for most of the stacks, the stack temperatures are very low. Due to the low stack temperatures all sulphur dioxide gas in the flue gas will dew in the stack and combine with the water present there and form sulphuric acid.
- The velocities of flue gases were also low. Due to the low velocity the pollutants may disperse locally because of low height of the installed stack.
- The SPM level is within limits of the proposed Nepali standard i.e. 450 mg/Nm^3 in all the stacks but in some (Morang) it is higher than the limits of the Indian standard i.e. 250 mg/Nm^3.
- There is a difference in temperature in the chimneys of the same shaft. It may due to the accumulation of moisture in the chimneys. As the factory is operating the kilns by partially closing the damper, the stack temperature has not risen even up to the sulphur dioxide dew point of 130 ^oC.
- High amount of smoke and gases are emitted through the top of the shaft because of the open lid and the partially closed damper. Under this condition, the safety of the workers is not ensured and their health can be affected while working on the top of the shaft.

On the whole Vertical Shaft Kilns definitely give low pollution load. But as the technology is new to Nepal, certain measures so that the temperature of the shaft is maintained at a higher temperature such as keeping the dampers open and the lid of the shaft closed should be practiced to give the maximum benefit to the industry as well as to safeguard the occupational health and ensure the safety of the workers.

Recommendations:

The following recommendation will help to reduce the coal consumption as well as SPM generations.

- Avoid using coal dust as an external fuel. But it can be used as internal fuel by mixing with the clay as filler.

- Maintain the stack temperature above Sulphur dioxide dew point 130oC by closing the shaft lid during operation so that the exhaust gases have to pass through the chimneys and retains heat in the shaft.
- Prevent leakage of the gases and ensure all the emission passes through chimneys by keeping the lid closed.
- As far as possible use properly dried green bricks.
- Reduce the consumption of coal and environment pollution by
  - Technical up-gradation as required for efficient use of energy.
  - Use of High quality coal having calorific value of around 5500 Calories with low sulphur content and producing low amount of dust
  - Conducting detailed energy audit
- Construct permanent sampling points
- Conduct detailed analysis of flue gases in regular intervals

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1. Introduction

Vertical Shaft Brick Kiln (VSBK) technology is an energy efficient technology for firing clay bricks. It is particularly suited to the needs of brick production in developing countries - which is of small scale and decentralized type. The evolution and initial development of VSBK technology tool place in rural China. The first version of VSBK in China originated from the traditional updraft intermittent kiln during 1960's. During the 70's, the kiln became popular in several provinces of China. In 1985, Chinese government commissioned the Energy Research Institute of the Hunan Academy of Sciences at Zhen Zhou (Hunan province), to study the kiln for improving its energy efficiency. Several thousand VSBKs are now in operation in China. Attempts to disseminate VSBK technology outside China started in the early 1990's. It was demonstrated in several Asian countries apart from India such as Afghanistan, Pakistan, Bangladesh, and Nepal.

In many ways, the introduction of VSBK technology in Nepal in late 2002 / early 2003 is an extension of the successful SDC funded India Brick Project in India. Here in Nepal, the project is known as the **VSBK Programme** (Nepal).

The VSBK Programme (Nepal) awarded Soil Test Pvt. Ltd this assignment to carry out Stack Monitoring of 20 chimneys of 10 shafts of VSBKs in the Jhapa, Morang and Lalitpur districts.

2. Methodology for stack emission monitoring

2.1 Stack sampling involves three major steps

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

2.1 Sampling points selections

The objective of stack sampling is to determine the amount of pollutant being emitted from the stack. For the proper sampling the location of the point should be selected carefully such that a laminar flow of air is present in the stack. To ensure the laminar flow the sampling port (for a circular diameter chimney) has to be located at least 8 times the chimney diameter downstream and 2 times upstream from 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

After selecting the sampling point, the number of transverse points has to be selected for the velocity measurement. The minimum required number of traverse points depends upon the stack or duct diameter. For the circular stacks the traverse points should be located symmetrically along each diameter and for rectangular stacks the

rectangular area should be divided into as many equal rectangular areas as there are traverse points.

2. 2. Velocity measurements

In these measurements the instruments used are S-type and L-type Pitot tubes with differential manometer to sense the Dynamic pressure of the stack which can be converted to the velocity. The inclined cum vertical differential manometer is capable of reading velocities as low as 3 m/s and up to the maximum 50 m/s with gauge oil of specific gravity 0.8 used as manometric fluid. At times when the velocity of the flue gas inside the stack is very low (less than 3 m/s) as in natural draft stacks, the velocity can be measured with the differential density manometer which provides an amplification of the reading by using two liquids (Aniline and distilled water) with a small difference in density. This manometer is capable of measuring the velocity from 0.7 m/s to 3.0 m/s

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

Calculations for velocity

Velocity (v) = $K\sqrt{2GHDm/Ds}$

Where, v = velocity (m/s)

K = Pitot calibration constant

G = Gravitational acceleration equal to 9.81 m/sec^2

H = Height of the manometer fluid

D_m = Density of manometer fluid

D_s = Stack gas density (kg/m^3)

The stack gas density is a function of the molecular weight of gases comprising the flue gas, the static pressure inside the chimney and the temperature of flue gas. To be scientifically exact, partial fractions of major constituents of the flue gas are 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 is determined.

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

$D_s = D_a^* Ta/Ts$

Where, D_a = density of a atmospheric air

T_a = Ambient air Temperature

T_s = Stack temperature

Velocity measurement averaged out by determining the velocity at different points across the cross-section.

Correction for ISOKINETIC Sampling

The measured velocity is used to calculate the ISOKINETIC sampling rate for a known nozzle. However, stack gases cool down as they pass through the sampling train and the rate of flow indicated in stack sampler is correspondingly corrected as per the gas law.

There will also be a pressure drop across the sampling train so that for an exact measurement of flow rate, corrections for the changes in both pressure and temperature have to be made.

2.2 Sampling

Stack monitoring was done by using Handy Stack Sampler Envirotech APM 620 and Stack Velocity Monitor APM 602. The methodology were followed as per the Indian Standards and the manual provided by the equipment supplier i.e. VAYU BODHAN UPKARAN PVT. LTD. New Delhi.

2.2.1 List of Equipment

The following equipments were used for the sampling of stack emission:

- Stack Velocity Monitor APM 602
- Differential manometer for velocity monitoring
- Handy Stack sampler APM 620 with vacuum pump
- Connections hose pipes and accessories.
- Stop watch and Mercury Thermometer.

2.2.2 Principle of Operation

APM 620 is a handy stack sampler. Flue gases enter the system through the Nozzle at the tip of the sampling probe, pass through the filter thimble, where Suspended Particulate Matter (SPM) is removed and reach the sampling train. Stack gas subsequently is discharged into the atmosphere through the vacuum pump. Provision has been made in the instrument to accurately measure the pressure drop across the thimble. Change in weight of the filter thimble is used to determine the quantity of dust contained in the flue gas sample, while a product of sampling rate and time is used to measure the sample volume.

2. 2. 3. Preparation for sampling site:

- According to stack diameter select the number and locations of the traverse points.
- Select the nozzle size of the dust collector according to the calculated velocity to ensure ISOKENITIC sampling.
- Take the stack temperature.

2. 2. 4. Thimbles Preparations

Prior to sampling the filter medium is dried and weighed. The pre-weighed thimble is loaded into the filter holder for particulate sampling. After completing sampling the filter thimble is dried prior to measuring the final weight.

2. 2. 5. Preparation for sampling

- Adjust the probe length according to the diameter of the stack and measure the velocity.
- Attach the dust collector to the probe.
- Mark the probe according to traverse points.
- Measure the Barometric pressure at the site and note in the data collection form.
- Measure the .ambient temperature and note in the data collection form.

2. 2. 6. Measurement of parameters

- Connect the pipelines through the chimney port hole to the vacuum pump then insert the probe into the chimney port hole and start the vacuum pump.
- Adjust the flow rate for ISOKINETIC sampling in the appropriate transverse point where the tip of the sampling probe can be located for obtaining a representative sample.
- After completion of the running time the sampling probes, the sampling probe is withdrawn and the thimble is carefully removed and transported to the laboratory for measurement, where the weight is determined after drying appropriately.

2. 3 Calculations

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

Dust emission rate (kg/hr) = S x Qs/10^6

Where Qs = Flue gas flow rate (25^0C, 760 mm Hg), Nm^3/hr and

S= dust Concentration in mg/m^3

Some formula and relation used for Calculations:

Law of Ideal gases

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

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

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

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

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

Flow calculation Duct area :

$$A = \frac{\pi \cdot d^2}{4}[m^2]$$

$$\text{Circumference} = 2 \cdot \pi \cdot r$$

Flow :

$$Q\left[m^3/h\right] = \mathrm{v}_{average}\left[m/s\right] \cdot A\left[m^2\right] \cdot 3600\left[s/h\right]$$

$$Q[\frac{Nm^3}{h}(wet)] = Q[m^3/h] \cdot \frac{273 \cdot P_{duct}}{T_{duct} \cdot 1013}$$

$$Q[Nm^3/h_{(dry)}] = Q[Nm^3/h_{(wet)}] \cdot \frac{100 - vol\%H_2O_{wet}}{100}$$

Particulate emissions

$$C[mg/m^3_{(n,d)}] = \frac{X[mg]}{Q_{sample}[m^3_{(n,d)}]}, where$$

$$C = Concentration[mg/m^3_{(n,d)}]$$

$$X = Differential\ weight\ of\ \ filter[mg]$$

$$Q_{sample} = Sample\ volume[m^3_{(n,d)}]$$

$$Emission[g/h] = Concentration_{dry} \cdot flow_{dry} =$$

$$\frac{C\left[mg/Nm^3{}_{dry}\right] \cdot Q\left[Nm^3{}_{dry}/h\right]}{1000\left[mg/g\right]}$$

3. Results and Analysis of Kiln Monitoring

As per the agreement a total 14 chimneys of 7 shafts were monitored to determine the Suspended Particulates Matters (SPM) in stack emission. Monitoring of VSBK kilns was completed in Jhapa, Morang and Lalitpur districts. In Jhapa and Morang districts all the operated shafts were sampled. In case of Lalitpur only two selected shafts were monitored.

During the monitoring following practices observed:

- The factories were operating the shafts without placing the covering lid on top of shaft.
- All the dampers in the chimneys were partially closed.
- High level of smoke was ensuing from the top of the open shaft.
- Moisture level was high in the chimneys due to the low stack temperature
- Dust coal was also used for the firing.

3.1. Results:

The obtained values of suspended particulates matters (SPM) are based on normal temperature and pressure of the particular locations condition. The detail industry wise results are given below.

3. 1. 1. Avi and Sabi VSBK, Morang

The kiln is located in Bhatigachha VDC of Morang district. Two shafts have been installed in the factory. On the day of monitoring only one shaft (shaft #1) was in operation on which the monitoring was conducted.

- Sampling were done on **27th March 2008**
- Total brick production of industry is 3,920 per shaft per 24 hours.
- The consumption of coal was 505 kg per 3,920 bricks i.e. 0.129kg per brick, i.e., 129 kg per 1000 bricks
- The size of the bricks was 250mm L, 120mm B, 78mm H.
- The area of the chimney is around 0.063 m^2 in the location of the sampling hole.

The obtained values of the stack monitoring are as follows:

S.N.	Location	Stack Temp ^oC	Velocity, m/s	SPM, mg/Nm^3
1	Shaft 1 West Stack	80	2.27	300.21
2	Shaft 1 East Stack	65	2.22	276.89

Note: Brick size: L: 250mm; B: 120mm; H: 78mm

Shaft Size: 1865 X 1070 mm

Remarks:

Stack temperature is very low**.** Due to the low stack temperature all sulphur dioxide gas condenses as dew in the stack and combines with the water and form sulphuric acid. The velocity of flue gas was also found to be low. Due to the low velocity, pollutants may disperse locally because of low height of stack installed. SPM level is within the limit of the proposed Nepali standard i.e. 450 mg/Nm^3, but is high as compared to the Indian standard i.e. 250 mg/Nm^3.

3. 1. 2 Su-Sweta VSBK, Morang

The kiln is located in Bhatigachha VDC of Morang district. Both the two shafts installed in the factory were in smooth operation. Measurements were made in all the four chimneys (two each of the two shafts)

- Sampling were done on **28th March 2008**
- Total brick production of industry is 3,500 per 24 hours per shaft.
- Two shafts were in operation.
- The consumption of coal was 588 kg per 3,500 bricks i.e. 0.163 kg (for shaft 1), i.e., 163.2 jg per 1000 bricks; 0.173kg (for shaft 2) per brick, i.e., 173 kg per 1000 bricks
- The size of the bricks was 250mm L, 120mm B; 72mm H.
- The area of the chimney is around 0.063 m^2 at the location of the sampling hole.

The areas of the all chimney are same. The obtained values of stack are as follows:

S.N.	Location	Stack Temp ^oC	Velocity, m/s	SPM, mg/Nm^3
1	Shaft 1 West Stack	94	2.42	254.42
2	Shaft 1 East Stack	105	2.34	222.69
3	Shaft 2 West Stack	55	2.18	295.59
4	Shaft 2 East Stack	86	2.40	274.66

Note: Brick size: L: 250mm; B: 120mm; H: 72mm

Shaft Size: 1865 X 1070 mm

Remarks:

Stack temperature is very low**.** Due to low stack temperature all sulphur dioxide gas dew in the stack and combine with the water and form sulphuric acid. The velocity of flue gas was also low. Due to the low velocity pollutants may disperse locally because of low height of the installed stack. SPM level is within limit as compared to the proposed Nepali standard i.e. 450 mg/Nm^3, but it is high as compared to the Indian standard i.e. 250 mg/Nm^3.

3. 1. 3. Jhapa VSBK, Jhapa

The kiln is located in Haldibari VDC of Jhapa district. There are two shafts installed and both were in smooth operation.

- The monitoring were done on **29th March 2008**
- Total brick production of industry is 3,840 per shaft per 24 hours.
- The consumption of coal was 464 kg per 3,840 bricks i.e. 0.093 kg per brick, i.e 93.75 kg per 1000 bricks
- The size of the bricks was 230mm L, 110mm B, 70mm H.
- The area of the chimney is around 0.0891 m2 at the location of the sampling hole.

The obtained values for the stacks are as follows:

S.N.	Location	Stack Tem ^oC	Velocity, m/s	SPM, mg/Nm^3
1	Shaft 1 West Stack	61	2.20	208.03
2	Shaft 1 East Stack	60	2.20	235.65
3	Shaft 2 West Stack	60	2.20	218.78
4	Shaft 2 East Stack	58	2.19	229.41

Note: Brick size: L: 230mm; B: 110mm; H: 70mm

Shaft Size: 990 X 1960 mm

Remarks:

Stack temperature is very low. Water droplets were observed in the stacks due to the low stack temperature. Due to low stack temperature all sulphur dioxide gas dew in the stack and combine with the water and form sulphuric acid. Velocity of flue gas obtained was low. Due to the low velocity pollutant may disperse locally because of the low height of the installed stack. SPM level is within limit as compared to both the Nepali (proposed) i.e. 450 mg/Nm^3 and Indian standards i.e. 250 mg/Nm^3.

3. 1. 4. Satya Narayan VSBK

The kiln is located in Imadol VDC of Lalitpur district. Six shafts have been installed. Two shafts (numbers 4 and 6) as selected by the client were monitored.

- The Monitoring were done on **17th April 2008**
- Total brick production of industry is 5,000 per shaft in shaft # 4 per 24 hours and 6000 pcs per shaft in shaft # 6
- The consumption of coal was kg per 5,000 bricks i.e. 0.109 kg (for Shaft # 4), i.e., 109 kg per 1000 bricks; 0.09297 kg (for Shaft # 6) per brick, i.e 92.7 kg per 1000 bricks
- Brick size is 230 mm L, 110 mm B, 55 mm H.
- The area of the chimney of shaft # 4 is around 0.04225 m^2 and the chimney of shaft # 6 is around 0.110 m^2 at the location of sampling holes.

The obtained values in normal condition of stack are as follows:

S.N.	Location	Stack Tem oC	Velocity, m/s	SPM, mg/Nm^3
1	Shaft 4 South Stack	47	2.16	160.56
2	Shaft 4 North Stack	58	2.19	159.08
3	Shaft 6 South Stack	48	2.65	131.95
4	Shaft 6 North Stack	47	2.64	114.25

Note: Brick size: L: 230mm; B: 110mm; H: 55mm

Shaft Size: Shaft # 4: 960 X 1920 mm

Shaft # 6: 1200 X 1920 mm

Remarks:

Stack temperature is very low. Water droplets were observed in the stack due to the low temperature. The total amount of sulphur dioxide that might be present in the flue would condense as dew and combine with the water to form sulphuric acid. Velocity of flue gas obtained was also low. Due to the low velocity pollutants may disperse locally because of low height of stack because they may not be swept away by the flow of the flue gas. However the measured SPM level is within the limits of the Nepali standard (proposed) i.e. 450 mg/Nm^3 and the Indian standard i.e. 250 mg/Nm^3.

3. 3. Comments and discussion

- There is a difference in temperature in the chimneys of the same shaft. It may due to the accumulation of moisture in the chimneys. As the factory is operating the kilns by only partially closing the damper, the stack temperature has not risen even up to the sulphur dioxide dew point of 130 ^{o}C.
- As the stack velocity was very low, the emitted flue gases disperse locally.
- High amount of smoke and gases are emitted through the top of the shaft because of the open lid and the partially closed damper. Under this condition, the safety of the workers is not ensured and their health can be affected while working on the top of the shaft.
- All the obtained values of suspended particulate matters are within the limits of the proposed VSBK kiln emission Standard in Nepal i.e. 450 mg/Nm^3. But for the factory in Morang they are also within the limits of the Indian standard i.e. 250 mg/Nm^3.

3. 4. Limitations and Justifications

– Only one traverse point was considered.
  - Due to low diameter of chimney velocity would be almost equal in every point of the traverse.

- Stack velocity was low so no significant differences of velocity at any point of the traverse.
- The sampling and velocity probes reached each and every point of the traverse.

– Damper was partially closed.
  - During the sampling period all the dampers were fully opened to make sure that the total volume of flue gases pass through chimney.

– Lid covers were not in place.
  - Lids of the stack were not available in all places. However after the dampers were fully open no leakages of flue gas through top of the shaft was seen.

– Low stack temperature.
  - The measurements were taken only one hour after the dampers were fully open

– High level of moisture in stack
  - After rising of stack temperature, the moisture evaporated and silica gel in the trap absorbed the moisture and prevents it from going to the sampling part of the instrument.

4. Conclusions and Recommendations:

The overall environmental performance of VSBK is found to be satisfactory. All the chimneys of VSBK where the monitoring was conducted were found to be within the proposed Nepali standard. However if comparison is to be made with the Indian standard some kilns need to improve their performance. The following are the standards set for VSBK kilns in India. Although the maximum value for PM has been kept in the proposed Nepali standard no standard for the height of the stack from ground level has been kept in that standard.

Emission Standards and Stack Height Regulation of VSBK, India

S. No.	Kiln Capacity	Stack Height in metres (from ground level)	Particulate matter (mg/Nm3)
1.	Less than 15000 bricks per day (1-3 shafts)	11.0 (Minimum 6.5 m from loading platform)	250
2.	15,000-30,000 bricks per day (4-6 shafts)	14.0 (Minimum 7.5 m from loading platform)	250
3	More than 30000 bricks per day (7shafts or more)	16.0 (Minimum 8.5 m from loading platform)	250

Recommendations

The following recommendation will help to reduce the coal consumption as well as SPM generations.

- Avoid using coal dust as an external fuel. But it can be used as internal fuel by mixing with the clay as filler.
- Maintain the stack temperature above Sulphur dioxide dew point – 130^{o}C
- Prevent leakage of the gases and ensure all the emission passes through chimneys

- As far as possible use green bricks with low moisture content.
- Reduce the consumption of coal and environment pollution by
  - Technical up-gradation as required for efficient use of energy.
  - Use of High quality coal having calorific value of around 5500 Calories with low sulphur content and producing low amount of dust.
  - Conducting detailed energy audit
- Construct permanent sampling points
- Conduct detailed analysis of flue gases at regular intervals

5. Monitoring Team

The Following experts are involved for stack monitoring of VSBK:

Dr. Krishna Ram Amatya- Senior Environmental Chemist (Team Leader)

Mr. Dinesh P. Sah- Environmental Chemist

Mr. Atul Baidya- Civil Engineer