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Full Length Research Paper

Impact of Air Pollutant on Human Health in Kushtia Sugar Mill, Bangladesh

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Abstract. The study dealt with the concentration of air pollutants emitted from Kushtia sugar mills in Jagati region of Bangladesh in order to evaluate their impact on human health. The dispersion of air pollutants from sugar mill's chimney was obtained through point source Gaussian dispersion model. The air pollutants were monitored during winter season in 2011-2012. A questionnaire survey was randomly carried out in a small scale at the study area. The result showed that the maximum concentration of SO_2, NO_x and PM_{10} were 28.837 µg/m^3, 76.177 µg/m^3 and 380.339 µg/m^3 respectively. The particulate matter (PM_{10}) concentration was found to be very high whereas sulfur dioxide (SO_2) and nitrogen oxide ($NO_{x)}$ concentrations were low at the study area. The calculated value of air pollution index (API) was 88.18 which indicate that heavy air pollution can predispose individuals to heart and lung disease in the study area people. This study revealed that the concentration of particulate matter found in Kushtia sugar mill had exceeded the minimum level according to the WHO standards. The high concentration of PM_{10} is suggested to affect human health and environmental conditions in the study area.

Keywords: Air pollutants, Kushtia sugar mill, Health impact and WHO standards

1. INTRODUCTION

The sugar industry of Bangladesh is one of the most vital agro based industries. It plays a versatile role in the economic progress of Bangladesh by way of creation of employment and related job sectors. Sugar industry is seasonal in nature and operates only for 120 to 200 days in a year (early November to April). A significant large amount of waste is generated during the manufacture of sugar and contains a high amount of production load particularly in items of suspended solids, organic matters, press-mud, bagasses and air pollution (Baruah et al., 1993; Sarala, 2012).

Sugardischarged into the environment poses a health hazard to the rural and semi-urban populations (Baruah et al., 1993). Currently, humans are facing severe health problems due to air pollutants which are prevalent in cities. It can be caused with several pollutants such as SO_2, NO_x, particulate matter and heavy metals (Suganthi et al., 2013). Air emissions from sugar production are primarily related to particulate matter generated from bagasse-fired steam boilers, and sugar drying or packing activities (Hove et al., 1999). The effect of particulate matter on vertebrate animals include impairment of respiratory system, damage to eyes, teeth and bones increased susceptibility to disease, pests or other stress-related environmental hazards and reduce ability to reproduce (Smith, 1975; Pope et al., 1995 and Blake & Rowland, 1995). Particulate matter that enters the lungs may lodge there and result in chronic respiratory problems including emphysema, pneumonia, bronchitis, asthma and respiratory tuberculosis, etc. Particulate matter associated with sugar mill operation may cause a mutation in the species by altering food chains, and affecting the ecosystem (Efe, 2008). When they combined with other gases and particulate matter they may become toxic and harmful to human health. Sugar mill is a significant contributor of major air pollutants to the atmosphere. The waste produce from sugar mill can be categorized into solid waste and gaseous wastes including total suspended particulates, CO, and NO_x. The main objective of the study was to determine the concentration of air pollutants emitted from sugar mill and to assess their impact on human health.

2. MATERIALS AND METHODS

2.1. Justification of sample site selection

It is noted that air pollutants cause an adverse effect on the human health. People are at risk due to rapid

industrialization and increasing number of sugar mills in the southwestern part of Bangladesh. Air pollution can be harmful effect on the respiratory system. Sugar mill workers and surrounding people who live in the Jagati area of Kushtia are simultaneously exposed to inorganic substances present in the air. A group of people were studied the environmental impact of water pollution in the Kushtia sugar mills effluent of Bangladesh (Sallequzzaman et al., 2008). But there is no study yet has been done to determine the concentration of air pollutants in Kushtia sugar mill of Bangladesh and their health impact. The health impacts of air pollutants are not disclose to the people. People of the surrounding of sugar mill are not concerned to environmental pollution. They are not aware about the health impact of air pollutants. In this context, this study was carried out in Jagati region of Kushtia sugar mill, Bangladesh.

Table 1: Emission factors of air pollutants in Kushtia sugar mill

Air Pollutants	Emission per MT* Cane Crushed (kg)
PM_{10}	1-1.5
SO_2	0.07-0.12
NO_x	0.2-0.3

*MT- Metric Tons per kg

Table 2: Emission of air pollutant in Kushtia Sugar Mill

Air pollutants	Emission (kg/h)
PM_{10}*	24.0625
SO_2*	1.82875
NO_x*	4.8125

*PM_{10}- Particulate Matter, *SO_2-Sulfer Dioxides, *NO_x- Nitrogen Oxides

Table 3: WHO standards vs. pollution concentration in surrounding area of Kushtia sugar mill

Pollutants	WHO Standard(µg/m^3)**	Surrounding Area of Kushtia Sugar Mills(µg/m^3)*
SO_2	100	28.3957
NO_x	150	76.1779
PM_{10}	150	380.889

(Source: *Calculation based on field survey data, **WHO, 2000)

2.2. Study area

The study was carried out in Kushtia sugar mill, Bangladesh in 2011-2012. It is situated at Jagati region under Kushtia sadar upazila in the Kushtia district. The area is characterized by Ganges flood plain sediment with calcareous dark grey soil (Mandal et al., 1998).The temperature of this area ranges from 30 to 34^0 C on average with an average rainfall of 1,458 mm (Banglapedia, 2009). Most of the people are engaged in agricultural work.

2.3. Methodology

The study was performed by using both qualitative and quantitative technique through primary and secondary data collection. The concentration of air pollutants from sugar mill's chimney was obtained through dispersion modeling. The study was conducted based on the basic point source Gaussian dispersion model (EEA, 2009). The computer based model is provided by USEPA (2006) and known as Industrial source complex model. The computer model required some emission and stack parameters as well as some meteorological parameters as input.

The USEPA regulatory guideline model ISC-3 (point source model) which is based on the steady-state Gaussian dispersion equation for estimating the downwind concentration and dispersion feature of the pollutants emitted from the sugar mill was used.

The general methods for estimating – $PM_{10,}$ SO_2 and NO_x emission from sugar mill was described by (IPCC, 1996)

$$\text{Emission}=\sum (\text{EF} \times \text{Activity}) \quad (1)$$

Where, EF=Emission Factor (Kg/MT); Activity=Baggas input (Metric Tons)

The air pollution index (API) values were computed by using Rao and Rao equation (1989). The average sum of the ratios of three major pollutant concentrations with respect to their air quality standards was carried out in the study. The equation was given below:

$$API=1/3[(PM_{10})/ (S_{PM10}) + (SO_2/S_{SO2}) + (NO_x)/(S_{NOx})]\times 100 \quad (2)$$

Where, S_{PM10}, S_{SO2}, and S_{NOx} represent the National ambient air quality standards (WHO) for PM_{10}, SO_2 and NO_x.

A structured questionnaire study was used to evaluate the health impact and requisite information of the inhabitant of the surrounding area due to operation of sugar mill. Inclusion criteria of the questionnaires were male & female, older than 18 year and permanent residents in the study area. People were known lung disorder which excluded in the study. Out of total population (117 people), only 10 % population of surrounding the sugar mill was taken as a minimum sample size (Berenson and Levine, 1992). For this study, stratified random sampling technique was adopted. Questionnaires were validated by the panel of expert including faculty member of Environmental Science discipline of Khulna University and researcher in public health service. Statistical analysis was done using MS excel 2007 software for calculation and made graph based on the questionnaire study.

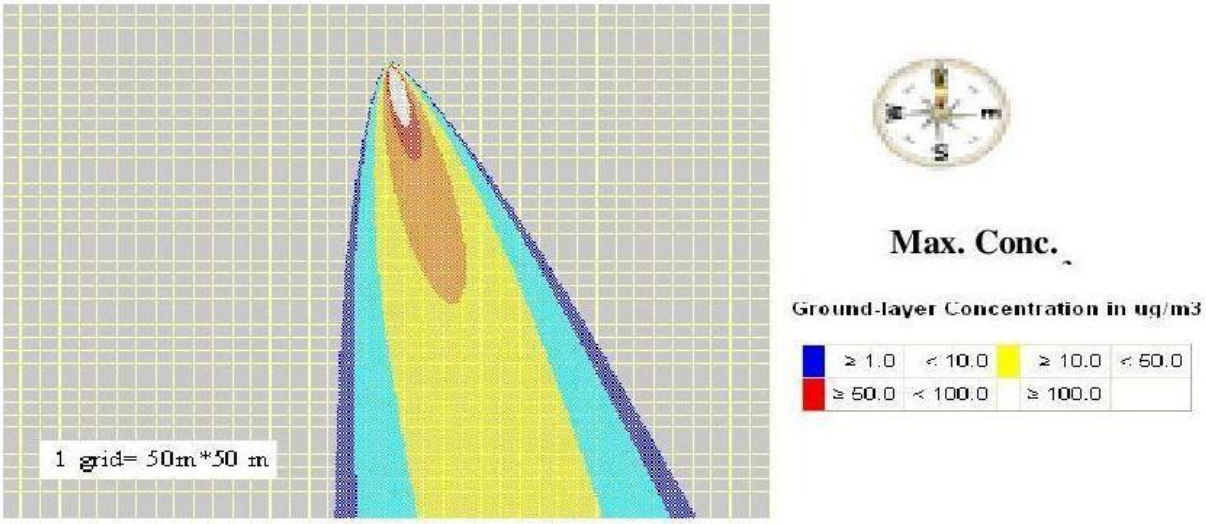

Fig. 1: The dispersion of PM_{10} from Kushtia sugar mills

2.4. Ethical consideration:

This research was a part of B.Sc. thesis of Environmental Science discipline, Khulna University and approved by ethical evaluation committee. Permission was taken from the general manager of Kushtia sugar mill, Bangladesh. Each of the participants gave their consent prior to their inclusion in the study.

3. RESULTS

3.1. Emission of air pollutants

Different type of air pollutants emitted from Kushtia Sugar Mill. The most significant pollutants emitted from bagasse fired boilers are PM_{10} and other NO_x, and SO_2 are caused by the turbulent movement of combustion gases. Emission factor of SO_2 and NO_x were found to be lower in amount while that of PM_{10} was higher in amount in study area when compared to the WHO standards (Tables 1 and 2).

Total amount of baggas = 462 Metric Tons/day. The emission was calculated based on emission factor which is the pollutant emission rate relative to the level of source activity.

3.2. Concentration of particulate matter (PM_{10})

It was found that the maximum concentration of PM_{10} was 380.889µg/m^3 during winter season in 2011-2012. So, the concentration of pollutants is very high in the adjacent Jagati area of the Kushtia sugar mill during winter season because of stable atmospheric condition (Fig. 1).

3.3. Concentration of nitrogen oxide (NO_x)

The maximum concentration of NO_x was found to be 76.1779µg/m^3 during winter season with reasonable limit compared with WHO standards (Fig. 2).

3.4. Concentration of sulfur dioxide (SO_2)

The maximum concentration of SO_2 was found to be 28.3957µg/m^3 during winter season. During winter season, highest mixing occurs in the atmosphere but the result show that concentration of SO_2 was within acceptable limit (Fig. 3).

3.5. Human health effect

Calculated value of air pollution index for the study area was 88.16 which belong to heavy air pollution at scale rating ranges 76-100 of air pollution performances indices. The result of the questionnaire survey revealed that 52% of the people of affected area suffered from respiratory problems such as cough, asthma, chronic bronchitis, emphysema while 25% people were unable to express their health status and 23% people had no problem at all (Fig. 4).

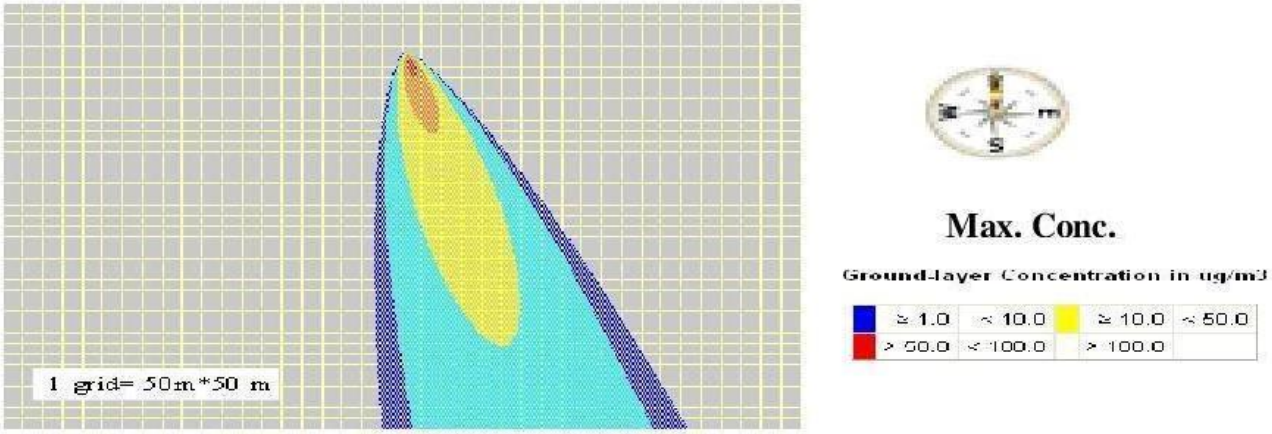

Fig. 2: The dispersion of NO_x from Kushtia sugar mills

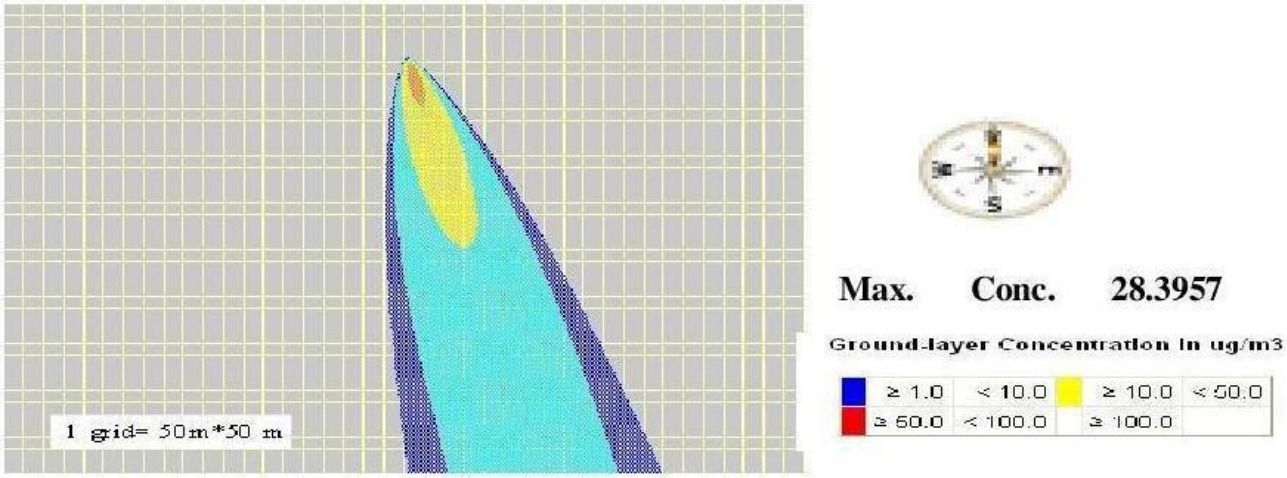

Fig. 3: The dispersion of SO_2 from Kushtia sugar mills

4. DISCUSSIONS

The result of this research revealed that the relationship between PM and other air pollutant such as NO_x and SO_2 which are the main element found in sugar mill effluent results in health respiratory problem. The air pollution level was studied for Kushtia sugar mills chimney from 2 km radius. The air pollutants were monitored on monthly basis. The PM_{10} concentration was found to be very high while the concentration of SO_2 and NO_x were found to be very low compared to the WHO standards. The curvilinear shaped curve (lower slope) show at higher concentration (PM_{10}) whereas monotonous shaped curve (steep slope) show at lower concentration (NO_x & SO_2) in the study area (Fig. 1, 2 and 3). Emission factor of air pollutants were utilized for controlling pollution to industrial waste sectors (USEPA, 2006; EEA, 2009 and Gains, 2010). A recent study show that industrial sector contribute the highest PM_{10} emission than other sectors (Guttikunda and Jawahar, 2012). The most substantial pollutant emitted from bagasse-fired boilers is the particulate matter (PM_{10}). Emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) are lower due to the low levels of sulfur and nitrogen associated with bagasse. Auxiliary fuels (typically fuel oil or natural gas) may be used during startup of the boiler or when the moisture content of the bagasse is too high to support combustion; if fuel oil is used during these periods, SO_2 and NO_x emissions increases. Soil characteristics such as particle size can affect the magnitude of particulate matter (PM_{10}) emitted from the boiler. Recent study was shown that dangerous air pollutants from sugar mills could contaminate the surrounding as far as 1 km away (Isabel et al., 2010). The frequency of

restrictive type of lung function abnormalities occurred among petrol pump worker due to increase air pollutant in the air (Alam et al., 2014).

Typically, the winter months are more polluted than the summer months for two reasons, precipitation is higher during the summer monsoon and the mixing layer height is lower during the winter months (Guttikunda and Jawahar, 2012). The main air pollutants such as PM_{10}, SO_2 and NO_x were recognized as a potential human health threat. There is connection between concentration of PM_{10} and human health includes respiratory infection (WHO, 2000). The impact from the combination of PM_{10} and other air pollutants may be harmful to human health. However, NO_x and SO_2 concentrations were within acceptable level in the study area when compared to WHO standards. World-Bank (2006) estimated 15,000 premature deaths per year due to air pollution from transportation and industrial emissions in Dhaka, Bangladesh. Wilson et al., (2000) argue that high PM concentration produce different type of health effect. The people living adjacently to the sugar mill are faced with odor problems. It creates uneasiness to the people. Weiss (2013) stated that outdoor and indoor air pollutants cause respiratory and other forms of diseases that may be fatal.

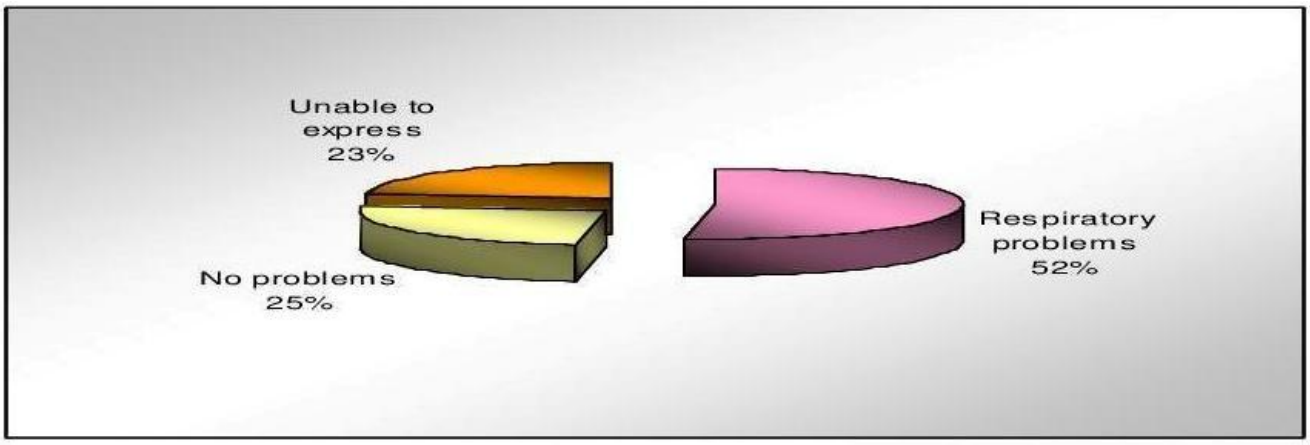

Fig. 4: People responses regarding health problems in the affected area of Jagati region in Kushtia sugar mill during 2011-2012.

In this study, the pollution level of the affected area was estimated and compared with the WHO air quality standards (Table 3). The study suggests that the high PM_{10} concentration in the atmosphere could be linked to the asthmatic condition suffered by people living in areas surrounding the sugar mill. Heavy air pollution was found in the study areas which adversely affect the human heart and lung. When particulate matter reach up to the terminal bronchioles invading the parenchyma causing chronic inflammation leading to restrictive pattern of lung diseases (Begum and Rathna, 2012). Questionnaire survey and laboratory analysis support a causal relationship between air pollution and adverse health effect. Ling (2004) stated that chronic respiratory illness occurred when fine particulate matter increased susceptibility in industrial areas. He also stated that the effect of PM_{10} has a strong association with respiratory effect and the risk increases with PM_{10} than $PM_{2.5}$. The people around sugar mill and the local inhabitants are constantly exposed to high concentration of air pollutants during sugar crushing period. Air pollution can cause and worsen heart and lungs diseases such as cancer. That is why the people exposed to the pollutants are in predisposed to severe respiratory illness. The result of the survey indicates that the people with lower education level and awareness seem to be more at risk to air pollution. More than 52 % respondent suffered respiratory problem out of 117 respondents in the area. People of lower education level were unable to express their health conditions (23 %), while the remaining other 25 % people living in the area seem to have no problems at all (Fig. 4).

5. CONCLUSION AND RECOMMENDATION

Kushtia sugar mill is one of the most robust industries in South-western region of Bangladesh. The present investigation was carried out to determine the concentration of air pollutants emitted from sugar mill and to assess their impact on human health. The study were investigated the concentration of (SO_2), (NO_x) and (PM_{10}) among the surrounding area of Kushtia sugar mill. Among these, the PM_{10} concentration exceeded the reasonable limit in relation to the WHO standards. The particulate matter emitted by bagasse-fired boilers was caused by the unstable movement of combustion gases with respect to the burning bagasse and their resultant ash. The concentration of SO_2 and NO_x were lower due to fact that bagasse are associated with low level of sulfur and nitrogen. The particulate

matter emission has to be controlled in the sugar industry with the help of fly ash arrestors. This study revealed that high concentration of PM_{10} has deleterious impact on both human health and surrounding environment in the study area.

The following recommendation can be made for minimizing the detrimental effect of Kushtia sugar mills effluent:

(1) To monitor and report the air quality regularly and produce reasonable limit of pollution by the sugar mill.

(2) To enlighten the people on how much pollution are caused by the sugar mill.

(3) To enforce existing law (BEPA, 1995) and regulation more strictly.

(4) To implement appropriate management strategy for minimizing human health effect in surrounding area of mills.

(5) To control air pollution from the bagasse of sugar mill as fuel boilers by using mechanical collector and wet scrubbers.

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