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Air Quality Measurement at the Solid Waste Disposal of Matuail Landfill Site at Dhaka, Bangladesh

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Abstract: An investigation was conducted to assess the air quality impact and possible health risk of solid waste disposal on surrounding environment of Matuail landfill site in Dhaka city. Three different locations were selected for soil and plant samples. Leachate samples were collected from active dumping area and fish samples from treated leachate pond. Seven different locations were selected for air quality and health risk assessments. It is found that Cu, Zn and Pb concentrations were high in the soil of dumping and abandoned areas that exceeded the permissible limits. The heavy metal concentrations in plant samples did not show any significant contamination except Cu, Zn and Pb that also exceeded the permissible limits. The concentrations of DO, BOD, COD and TDS of the untreated leachate were found 1.34 mg L^{-1}, 96 mg L^{-1}, 1343 mg L^{-1} and 7120 mg L^{-1}, respectively that exceeded inland surface water standard but after treatment its concentrations were found within the permissible limits. The presence of heavy metals in leachate sample was not contaminated as it was below the toxic limits. The bioaccumulation of fish sample from treated pond is extremely high of Fe, Mn, Pb and Ni that exceeded the WHO's permissible limits. The air quality results showed that the Matuail landfill surrounding sites did not have an adverse effect. The air pollutants such as NOx, SO_2, SPM, PM10, PM2.5 and CO contents are within national standard limits. Overall, the risk assessments demonstrated that potential air emissions from the Matuail Landfill site do not pose public health risks. It is clear that if the dumping landfill site is properly managed by segregating the waste according to their source, then this waste could be used as compost or organic manures. However, by maintaining disposal sites with controlled placement and proper treatment of the waste may reduce the possible adverse impact on air, human health and agri-environmental eco-systems. Further investigation on the impacts related to the final disposal of solid waste and the future landfill requirement at different composting and a comparative study is suggested.

Keywords: Air Quality, Solid Waste Disposal, Contamination, Human Health Risk, Agri-Environmental Eco-Systems

Introduction

Rapid growth of industries, inadequate trained manpower, inappropriate technology and lack of awareness of the community are the major constraints of solid waste management and its impact on air quality for the fast growing metropolis of Dhaka, capital of Bangladesh (Jahan *et al*., 2016; Hossain *et al*., 2018; Aljerf, 2018). This waste comprises of 46.8% domestic, 21.8% street sweeping, 19.2% commercial, 12.9% industrial and 0.5% clinical wastes along with other waste disposal option such as storage, recycling, combustion, composting and disposal units for both municipal solid waste and hazardous waste (Salam, 2001). Although all the solid waste management units at the facility are strictly regulated by the Dhaka City Corporations that are designed to protect human health and the environment, these units, like those operated at other solid waste management facilities nationwide, have the potential to emit compounds present in materials received at the facility into the air.

Decomposed solid waste has both positive and negative impact on the air quality. Solid waste contains significant quantity of degradable organic matter which may enrich the nutrient status of soil. To illustrate, if they are properly managed by segregating the waste according to their source it can be used on agriculture after composting (Singh and Mahour, 2012). Conversely, if these wastes cannot be controlled in proper manner, then they can bring detrimental effects on surrounding environment including air, soil, surface and ground water. The soil becomes contaminated by the toxicity of the constituents of wastes, as a result the natural composition of soil is disturbed, which may spoil the top soil and pollutes the sub soil and its air. Leachate from decomposed solid waste conveys heavy metals such as Fe, Cu, Cd, Ni, Pb, Zn etc. and toxic chemicals (Haque *et al*., 2013). If the water source is mixed with the leachate it becomes polluted and will be a threat to water and aquatic life. Usually the adjacent areas of the dumping site are used as cropping field by the local people and in this way hazardous substances may be accumulated by the plant from the decomposed waste and leachate from the dumping site (Rasool *et al*., 2016). After dumping the waste under soil, the hazardous volatile organic compound may causes detrimental effects on the health of the people living around the disposal site of the solid wastes (Saini and Kaur, 2018).

The manner of solid disposal is simply dumping and spreading of waste. The concentration of heavy metals in solid waste in this landfill site was found to be very high which could be potentially hazardous and possess serious threat to air, soil and water (Mamtaz and Chowdhury, 2006). Leachate from decomposed solid waste (municipal, industrial and clinical) conveys heavy metals such as Fe, Cu, Cd, Ni, Cr etc. (Haque *et al*., 2013) that may get into surface water body or percolate groundwater causing potential water contamination. Such contamination of water resources may possess substantial risk to the local natural environment. Areas near landfills have a greater possibility of groundwater contamination because of the potential pollution source of leachate originating from the nearby landfill site unless significant thickness of natural clay lining or artificial lining (i.e. geo-textile) is in place (Mor *et al*., 2006). Besides, vegetation damage, unpleasant odors are major concerns.

Particulate matter (PM) includes dust, dirt, soot, and smoke that are directly emitted into the air by solid waste materials decomposition, cars, trucks, buses, factories, construction sites and wood burning to name a few examples. Other particles are formed in the air when gases from burning fuels react with sunlight and water vapor. Such gases, from partially decomposed waste materials, incomplete combustion in motor vehicles, at power plants and in other industrial processes, contribute indirectly to particulate pollution (Hiwata and Koho, 2003). This pollution can cause chronic bronchitis, asthma attacks, decreased lung function, coughing, painful breathing, cardiac problems and heart attacks, as well as a variety of serious environmental impacts such as acidification of lakes and streams and nutrient depletion in soils and water bodies (Ding *et al*., 2017).

Several studies carried out to quantify the contamination of soil, surface and ground water in the dumping waste at Matuail landfill site (Zahur, 2007; Mamtaz and Chowdhury, 2008; Azim *et al*., 2011; Haque *et al*., 2013; Jahan *et al*., 2016; Hossain *et al*., 2018) but none of the studies have identified yet for its impacts of air emission and health risk assessments, hence, the current research objective is to find out the air quality and several health risk assessments. These investigations include monitoring of chemical concentrations in air, soil, fish and leached water using USA approved sampling methods and also health risk assessments that follow USEPA guidance. Together, these investigations provide a scientific database on air quality at the site and support a common conclusion that poses risks to surrounding of Matuail Solid Waste Landfill Site.

Materials and Methods

Matuail landfill site is located on the north of Dhaka-Demra highway which lies between latitude 23°42.97' and 23°43.35'N and longitude 90°26.83' and 90°27.2'E. Approximately1800 to 2000 tons of waste is coming here every day and the manner of disposal is simply dumping and spreading of waste. It is a semi-aerobic landfill which is in pipe system, half circle of it is solid in lower part and upper half is perforated where natural air is passed by. Leachate from dumping site is stored in leachate pond, which is treated with lime, $FeSO_4$, polymer etc. and stored in another pond (treated leachate pond) then discharged. Some fishes are cultured in treated pond. A GIS-GPS based location map of Matuail landfill site is shown in Fig. 1.

Soil samples were collected from three areas i.e. abandoned landfill area (AbS; in this area dumped waste had been covered with soil to close the site), dumping area (DmS; consists of partially decomposed waste after removing the upper waste part) and surrounded agricultural area (AgS; surrounded area of the landfill used for agriculture). The composite soil samples were collected at 0-15 cm depth by the Soil Survey Staff (USDA, 1951). Leachate samples were collected from both treated (TLP) and Untreated Leachate Ponds (UTLP) and discharged path of treated leachate waste-water i.e. used for irrigation (IL). Composite plant samples were also collected from each area. Tilapia fish (*Oreochromisniloticus*) (TPF) samples were collected from the treated pond at the sites. Soil, plant and fish samples were air dried, ground and sieved for chemical analysis.

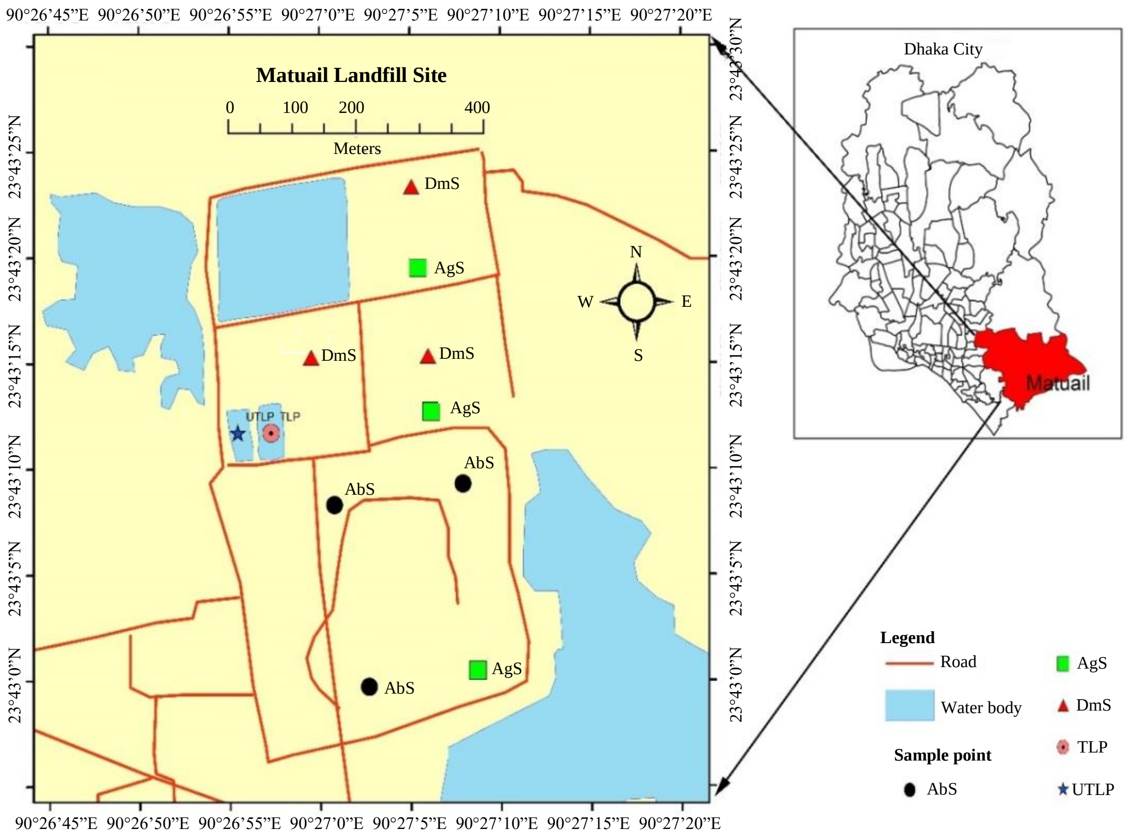


Fig. 1: GIS-GPS based location map of matuail landfill Site in Dhaka City

For determination of total N of soil, plant, leachate and fish samples Kjeldahl method was used (Jackson, 1962). Total concentration of P, K, S, Fe, Mn, Cu, Zn, Pb, Cd and Ni in soil, plant, leachate and fish were analyzed by digesting soil with aqua-regia at a ratio of 1: 10, leachate with concentrated nitric acid, plant and fish with nitric acid followed by perchloric acid. Total phosphorus was estimated colorimetrically using a spectrophotometer by developing yellow color with vanadomolybdate, total potassium by flame photometer and total sulfur by turbidimetric method using spectrophotometer, available N, P, K and S in soil by 1N KCl, Bray and Kurtz solution, 1N ammonium acetate and Morgan's solution, respectively were used as an extracting agent (Jackson, 1962). Soil was extracted by using 1N HCl with a ratio of 1:33.33 in case of available Fe, Mn, Zn, Cu Pb, Cd and Ni determination (Chowdhury *et al*., 2010). After digestion the concentrations of Fe, Mn, Cu, Zn, Pb, Cd and Ni in soil, plant, leachate and fish samples were estimated by Atomic Absorption Spectroscopy. The pH, DO (dissolve oxygen) and TDS (total dissolve solid) of water samples was determined by using portable pH meter, DO meter and TDS meter, respectively. The BOD was measured by refrigerated thermal autoning machine (FTC 90E). The COD (Chemical oxygen demand) was determined by $K_2Cr_2O_7$ in 50% H_2SO_4 and the remaining amount of $K_2Cr_2O_7$ is titrated with a standard Mohr's salt (0.125N $FeSO_4 (NH_4)_2 SO_4$) solution (APHAWEF, 2012). The statistical analyses were done using software Stata version 12.

The air quality monitoring was carried out at 7 locations in and out of landfill areas and all the locations along with GPS coordinates are summarized statistically.

The parameters monitored were, Oxides of Sulphur (SOx), Oxides of Nitrogen (NOx), Carbon Monoxide (CO), Total Suspended Particulate Matter (SPM), Particulate Matter (PM10) and (PM2.5) LATA Envirotech APM 250 with Combined PM10 and PM2.5 sampler was used for the measurement of particulate matters and for gaseous pollutants LATA Envirotech LES 411 was used for monitoring. To monitor carbon monoxide (CO) HTC CO-01 meter was used and value is expressed in ppm. The monitoring work started on June 30, 2018 and ended on July 2, 2018. The weather was mostly sunny during the monitoring period. The duration of monitoring was 8 hours. Proper Personnel Protective Equipment (PPE) including vests and helmets were used during the monitoring period. Exact location of Air Quality measurement equipment of High Volume Sampler Gaseous Sampling LES 411 HTC Carbon Monoxide Meter CO-01 was used.

Results and Discussion

Physicochemical Properties of Soils in and Around the Landfill Site

The pH of the studied soil samples were slightly acidic having pH ranges from 5.9 to 6.7 (Table 1). The slightly acidic nature of pH might reflect the abundance of organic waste in this site but previous research showed). The highest value (17.4%) of moisture conten t was recorded in dumping area (DmS) whereas the that incoming bio-waste like food waste was characterized by low pH between 4.7 and 6.1 (Norgaard and Sorheim, 2004 lowest value (5.9%) was recorded in abandoned area (AbS) in the studied landfill site.

However, a substantial amount of organic matter was observed in the entire area of the studied landfill site. It was also observed that the OM content in dumping area two times higher than the abandoned area and four times higher than the agricultural areas (Table 1), mainly due to the abundance of decomposed organic waste (household waste) in the dumping area. The CEC of this studied soil was comparatively higher in dumping area than the other areas such as AbS and AgS because of high OM content on the dumping area. This possibly reflects that cations held on the organic matter particles in soils can be replaced by other exchangeable cations that increase the CEC of soil. The maximum value of N was recorded at the dumping area, whereas the minimum was observed in surrounded area of the landfill. Analysis of variance reveals significant difference of N within three different areas such as AbS, DmS and AgS of the studied landfill site ($p \leq 0.001$), due to the variation of OM content in those areas. The available N concentration was also observed high in dumping area than other areas (Fig. 3). The relationship between available soil N and total N concentration was found to be significant and positive (r = 0.74***) (Table 2). The available soil N was significant and positively correlated with OM (r = 0.86***) and CEC (r = 0.91***) (Table 3), indicated that OM is an important regulating factor of the content of available N in soil.

Considerable amounts of P were found in the studied landfill area. The total and available P concentrations were highest in dumping area (Fig. 2 and 3) and showed a significant difference in both abandoned and surrounded landfill areas ($p \leq 0.001$). The available P concentration is low in compare with total P concentration, may be due to the abundance of Fe in the landfill site that may fixed the excess P (Jokubauskaitė *et al*., 2015). The relationship between total and available P was positively significant (r = 0.86*** Table 2). Soil available P showed a significant and positive correlation with soil OM (r = 0.97***) and CEC (r = 0.81***). It could reflect that the available P concentrations were increased with the increasing of CEC and OM. The total K concentration was more or less similar in entire landfill areas such as AbS, DmS and AgS was not significantly different from each other. The results showed no clear trend for total *K* in three different areas but the available *K* concentration was found significantly higher ($p \leq 0.001$) in dumping area than surrounded area might be due to the abundance of *K* containing waste in dumping area. The available *K* concentration was positively correlated with total *K* but statistically not significant. Soil available *K* was significantly and positively correlated with soil pH (r = 0.59**), OM (r = 0.79***) and CEC (r = 0.47*). The total S concentration was significantly varied in three different areas of the landfill site ($p \leq 0.001$). The maximum value of S was recorded at dumping area whereas the minimum was found in both the abandoned area and surrounded agricultural area (Fig. 2). But the available S concentration was higher in surrounded agricultural area (AgS) than the DmS and AbS (Fig. 3). In DmS area most of the sulphur may be present in organically bounded form due to the abundance of organic waste. A negative and very poor relationship was found between total and available S. No significant correlation was observed between soil available S and soil properties.

The Fe concentration was found highest in abandoned area (Fig. 4) and it was significantly differed ($p \leq 0.001$) from both dumping and surrounded areas. The overall Fe concentrations in the studied landfill site were present within the permissible limit (Kabata-Pendias and Pendias, 2000). Previous study was found more or less similar concentration of Fe (12249 $\mu g\ g^{-1}$) in decomposed waste but lower concentration of Fe in converted soil (3411 $\mu g\ g^{-1}$) at that landfill site (Haque *et al*., 2013). The available concentration of Fe was comparatively higher in the entire landfill site might be due to the low pH, because low pH increases the availability of Fe. A positive but insignificant relationship was found between total and available Fe (r = 0.18) (Table 2). No significant effect was observed for available Fe in soil properties (Table 3).

Table 1: Physicochemical properties of studied soil sample in and around the landfill site

Areas	Denotation	pH	Moisture %	OM %	CEC (meq/100g)
Abandoned	AbS	6.1±0.04	5.9±0.8	6.4±0.7	8.2±0.4
Dumping	DmS	5.9±0.14	17.4±1.3	11.9±1.1	10.6±0.9
Surrounded Agriculture	AgS	6.7±0.3	9.5±1.7	3.2±0.03	8.2±0.2

Table 2: Relationship between total and available nutrient concentrations in soil

	Total nutrient conc. in soil										
	N	P	K	S	Fe	Mn	Cu	Zn	Pb	Cd	Ni
Available nutrient conc. in soil											
N	0.74***										
P		0.86***									
K			0.02								
S				-0.02							
Fe					0.18						
Mn						0.96***					
Cu							0.99***				
Zn								0.98***			
Pb									0.99***		
Cd										0.96***	
Ni											0.86***

Note: ***indicates 0.1% level of significance

Table 3: Relationship between soil properties and soil available nutrient concentrations

	← Relationship between soil available nutrient and its properties →		
	pH	OM	CEC
N	-0.09	0.86***	0.91***
P	0.36	0.97***	0.81***
K	0.59**	0.79***	0.47*
S	0.19	0.01	0.19
Fe	0.25	-0.03	-0.03
Mn	0.44*	0.68***	0.29
Cu	0.26	0.86***	0.66***
Zn	0.31	0.85***	0.66***
Pb	-0.42*	0.03	0.13
Ni	0.32	0.82***	0.62***
Cd	0.29	0.79***	0.60***

Note: *, **, *** indicates 5%, 1% and 0.1% level of significance, respectively

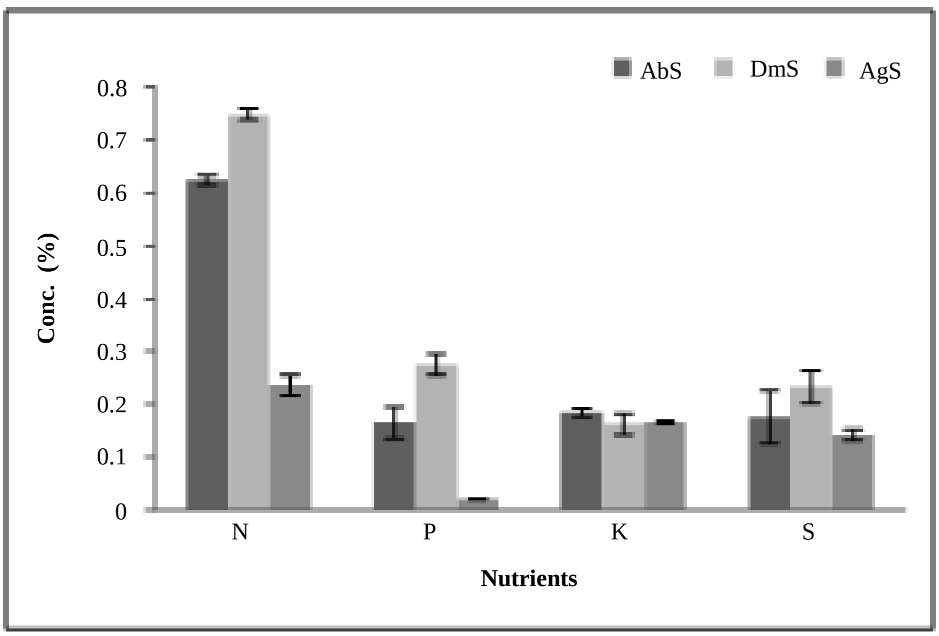


Fig. 2: Concentrations of total nutrient in soil at different areas

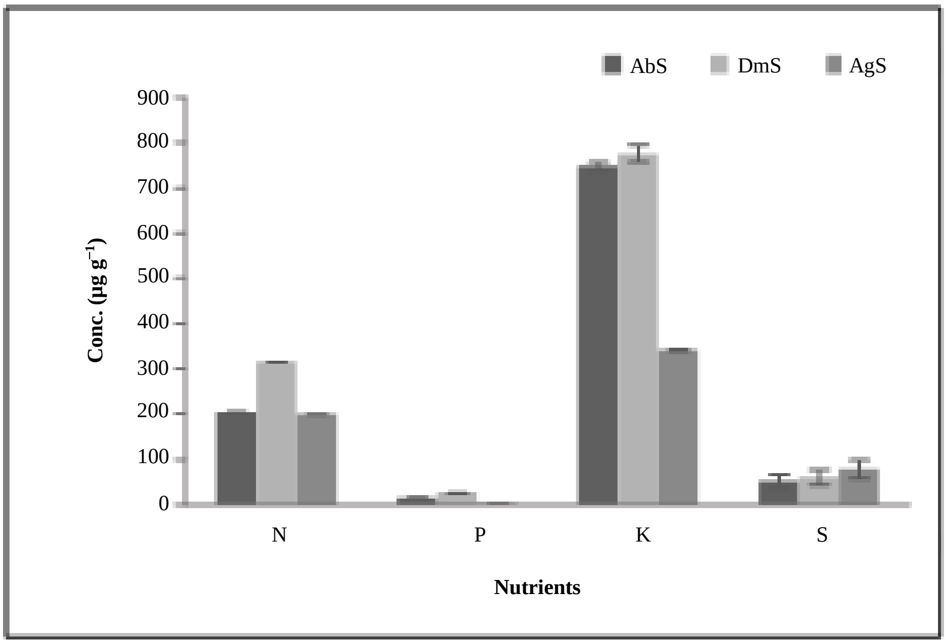


Fig. 3: Concentrations of available nutrient in soil at different areas

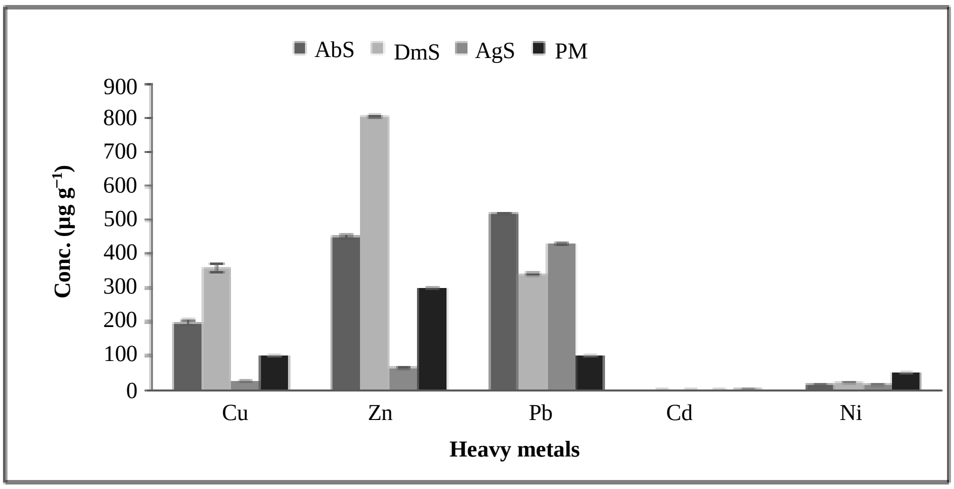


Fig. 4: Average concentrations of heavy metals in soil at different areas of the landfill site

The total concentration of Mn was significantly higher in both abandoned area and dumping area than surrounded area ($p \leq 0.001$) but the average Mn concentration not exceeded the toxicity level in the studied sample (Kabata-Pendias and Pendias, 2000). A significant positive correlation (r = 0.96***) was existed between the available Mn and total Mn and available soil Mn was significant and positively correlated with pH (r = 0.44*) and OM (r = 0.68***) (Table 2).

Figure 3 showed that the higher value of Cu (422 µg g^{-1}) in the dumping area than the surrounded area. ANOVA revealed that the value of Cu in DmS was significantly differed from the AgS ($p \leq 0.001$). The Cu concentration in abandoned area and dumping area was exceeded the permissible limit (Kloke, 1980), might be due to the presence of Cu containing waste in this site. A significant and positive correlation was found between the available Cu and total Cu (r = 0.99***, Table 2). Available soil Cu was significantly and positively correlated with OM (r = 0.86***) and CEC (r = 0.66***, Table 3).

The concentration of Zn was recorded highest (854 µg g^{-1}) in the dumping area compared with the other two areas (Fig. 4 and 5) and significantly differed

($p \leq 0.001$) from the both areas. The value of Zn in AbS and DmS was exceeded the permissible limit (Kloke, 1980) may be because of the dumping of Zn containing waste such as kitchen waste, ash, plastic, paper, dry cell batteries, glass, paint pigment etc. that may contribute to increase the Zn concentration on that area. A significant positive correlation was observed between soil available Zn and total Zn (r = 0.98***, Table 2). The available concentration of Zn shows positive and significant relationship with soil OM (r = 0.85) and CEC (r = 0.66***, Table 3).

The average concentration of Pb in entire studied areas of the Matuail landfill site was exceeded the permissible range (Kloke, 1980). Disposal of different waste material such as electrical goods, electroplating waste, batteries might contribute to increase the Pb concentration in this site is well agreement with previous study (Mamtaz and Chowdhury, 2008) and also observed a very high concentration of Pb in converted soil (1449 $\mu g\ g^{-1}$) than decomposed waste (328.26 $\mu g\ g^{-1}$). The available Pb concentration of the studied area was observed comparatively high and positively correlated with the total Pb (r = 0.99***, Table 2). The low pH might be increased bio-availability of Pb. Soil available Pb was significantly and negatively correlated with pH (r = -0.42*, Table 3). The concentration of Cd was observed higher (0.8 $\mu g\ g^{-1}$) in both abandoned and dumping area than the surrounded agricultural area (Fig. 4). The value of Cd was found below the permissible limit (Kloke, 1980) and their concentration was lower than the previous study conducted by Haque *et al*. (2013), who reported that Cd in decompose waste and converted soil was 1.27 $\mu g\ g^{-1}$ and 0.61 $\mu g\ g^{-1}$, respectively. A significant positive correlation (r = 0.96***) was found between soil total and available Cd (Table 2 and Fig. 5). Soil available Cd shows a significant and positive correlation with soil OM (r = 0.79***) and CEC (r = 0.60***, Table 3). The value of Ni in dumping area (DmS) was significantly ($p \leq 0.001$) differed from both abandoned and surrounded agricultural areas and its content did not exceed the permissible limit (Kloke, 1980). Available Ni was significant and positively correlated with soil OM (r = 0.82***) and CEC (r = 0.62***, Table 3).

Nutrient and Heavy Metal Concentrations in Plant Sample

The nitrogen and phosphorus concentration of plant samples were recorded higher in the dumping area than both of the abandoned area and the surrounded agricultural areas (Fig. 6). It reflected that dumping area contains high concentration of available N and P which might be interpreted the high concentration of N and P in the plant of dumping area but ANOVA revealed no significant difference of N and P concentration between the plants of different areas of the landfill site. The K concentration in plant of surrounded area was found higher (5.44%) than the abandoned area (4.76%) and dumping area (4.01%). It might be due to the abundance of coarse particles in the dumping area than the surrounding agricultural area that might contribute to leach K below the plant root zone and discharged leachate in the surrounding vegetation which contain high nutrient.

The concentration of Fe in plants was lowest (178 $\mu g\ g^{-1}$) in the dumping area whereas highest (837 $\mu g\ g^{-1}$) in the abandoned area, but did not exceed the permissible limit (Kabata-Pendias and Pendias, 2000).

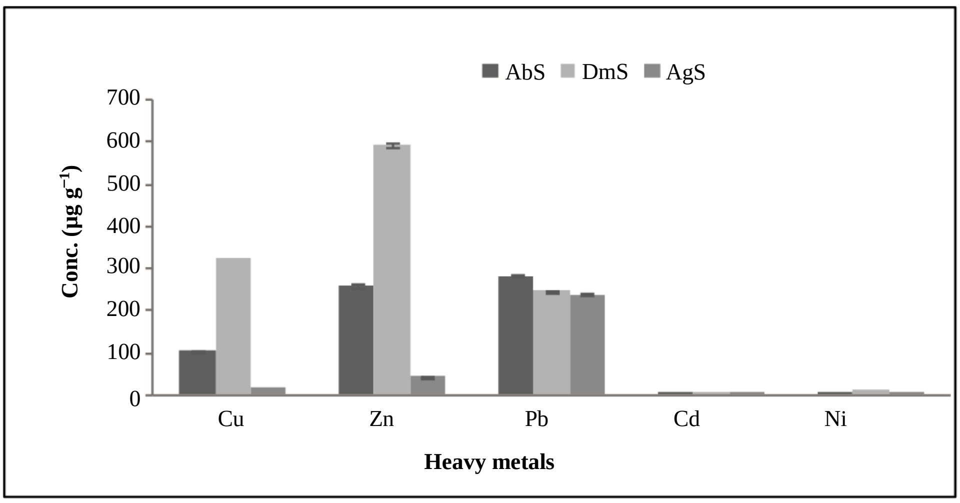


Fig. 5: Average concentrations of available heavy metal in soils

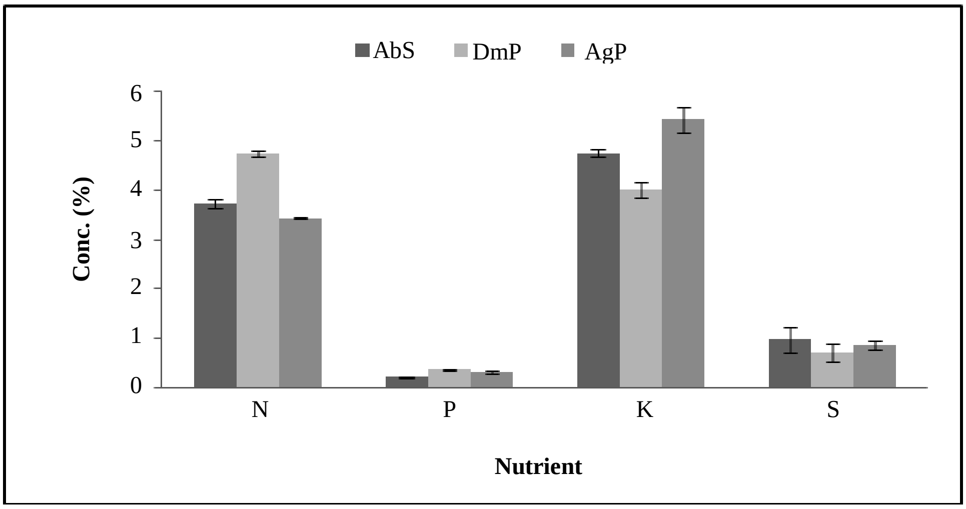


Fig. 6: Concentrations of nutrient in studied plant sample

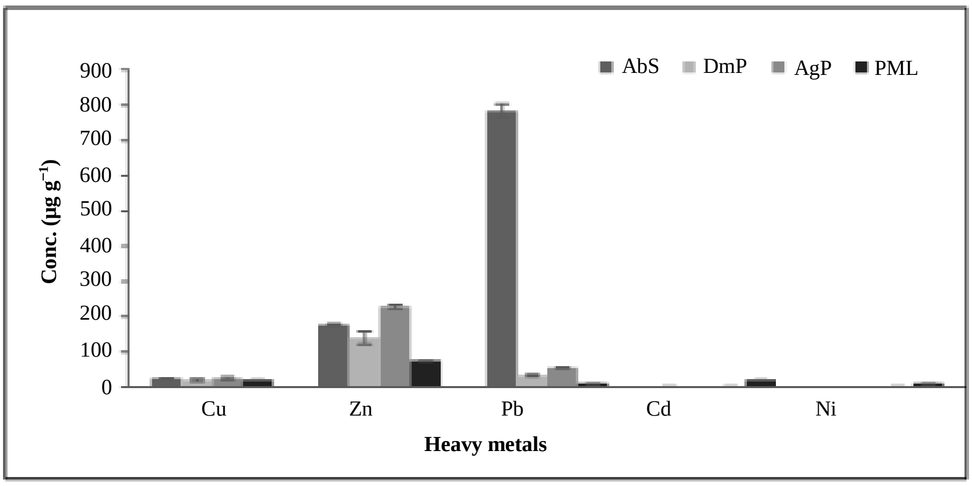


Fig. 7: Concentrations of heavy metals in plant

In dumping area the partially decomposed solid waste was present in the upper part that may causes root restriction and retards nutrient uptake by plant which might be interpreted the minimum concentration of Fe in the plant of dumping area. The value of Mn in plant of surrounded agricultural area was found (83 μg g^{-1}) significantly higher than the other areas ($p \leq 0.001$), but not exceeded the permissible range (Kabata-Pendias and Pendias, 2000). Further work would be needed to find the causes of this apparent result with any certainty. The concentration of Cu in plant was observed more or less similar in the entire area (Fig. 7) and no significant difference was found among them. The Cu concentration of plant in almost all areas were exceeded the permissible limit (Sauerbeck, 1982), might be due to the high concentration of available Cu in the soil of entire area. The concentration of Pb was significantly higher (784 μg g^{-1}) in the plant of abandoned area than the other areas ($p \leq 0.01$). The overall Pb concentration in plant samples of the studied landfill site was exceeded the maximum allowable limit (Sauerbeck, 1982). It reflected that the high concentration of Pb in the soil of landfill area might contribute to increase the Pb accumulation of plant. Figure 7 illustrated that plants in the surrounded agricultural area accumulated higher Zn (229 μg g^{-1}) than the dumping area. The concentration of Zn in plant sample of almost all areas was found above the permissible limit (Sauerbeck, 1982) might be due to the abundance of available Zn in entire soil of the studied area. All the values of Cd were found below the permissible limit (5-10 μg g^{-1}; Sauerbeck, 1982) in the entire area of the landfill site (Fig. 7). The values of Ni were also observed below the maximum permissible limit (10 μg g^{-1}; WHO, 1989) in different areas of the landfill site. No significant difference was found for Cd and Ni in plant of different areas.

Physicochemical Parameters of Leachate at Waste Dumping Site

The pH value ranges from 8.00 to 8.23 that confirmed the slightly alkaline in nature of the leachate sample. The measured pH value shows that all the samples are within the permissible limit given by Department of Environment (DoE; pH 6 to 9). The maximum DO are recorded in treated leachate pond (7.49 mg L^{-1}) that while the minimum (1.34 mg L^{-1}) recorded at untreated leachate pond (Fig. 8). The discharged leachate sample showed lower value of DO than the treated leachate sample which is reflected that untreated leachate might be mixed with the treated leachate in the discharged path. Previous study also observed lower value of DO in untreated leachate (0.9 mg L^{-1}) than the treated leachate (1.4 mg L^{-1}; Azim *et al*., 2011). According to DoE (2003), the treated leachate was succeeding to keep the DO value within the permissible limit (4.5 to 8). The concentration of BOD in treated leachate sample is present within the permissible limit according to DoE (50 mg L^{-1}), whereas the BOD in UTLP is exceeded its limit (Fig. 8).

The concentration of COD in untreated leachate sample was supported by another study where COD was found 1630 mg L^{-1} but in treated leachate the value of COD differed from that study (Azim *et al*., 2011), where COD was found 1436 mg L^{-1}. The value of COD in different leachate samples was exceeded the permissible limit (250 mg L^{-1}) which may consequently affect the aquatic life. The results shows that the TDS value of the treated leachate is below the permissible limit but untreated and discharged leachate lies above the limit (Fig. 8). A similar result finding is well documented for TDS of untreated leachate sample (7178 mg L^{-1}) but for treated leachate sample (Haque *et al*., 2013), showed higher value of TDS (6637 mg L^{-1}) compared with the present study (790 mg L^{-1}).

The Fe concentration of all leachate samples exceeded the standard limit of surface water due to the high concentration of Fe in the soil of landfill areas. According to DoE (2003), the concentration of Mn in this study lies within the permissible limit (5 mg L^{-1}) as compared with inland surface water standard. Hence, leachate samples are not contaminated by Cu and Zn due to their presence within the permissible limit. In the present study the leachate sample has shown no appreciable concentration of lead and it was found below the permissible limits. The Cd concentration in different leachate samples was found below the detection limit. The concentration of Ni is lower than the previous study (Azim *et al*., 2011); where Ni concentration ranges from 1.048 μg g^{-1} (untreated leachate) to 0.097 μg g^{-1} (treated leachate).

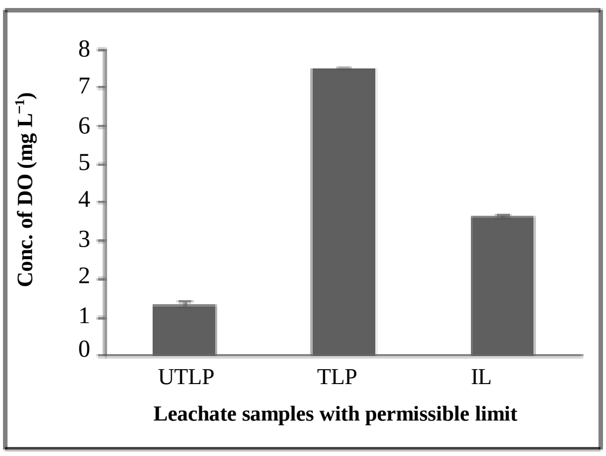
Nutrient and Heavy Metal Accumulation Intilapia fish from Treated Leachate Pond

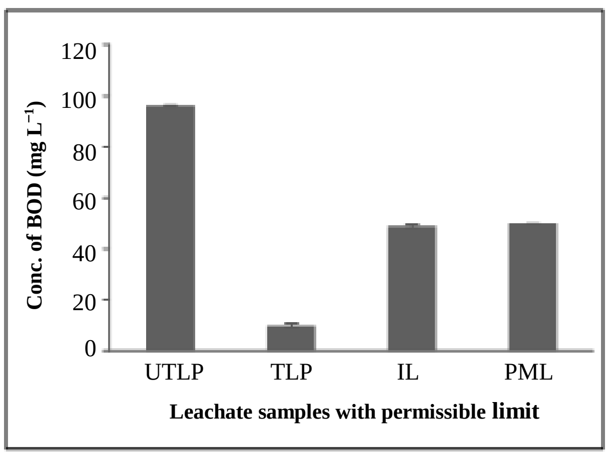
Fish are important aquatic organisms that are used as bio-indicators of aquatic ecosystems for estimation of heavy metal pollution and risk potential for human consumption (Agarwal *et al*., 2007). Bioaccumulation of metals in fishes takes place directly, from the water by gills and indirectly from food (Barron, 1990).

Table 4: Concentrations of Fe, Mn, Cu, Zn, Pb, Cd and Ni in sediment and fish from treated leachate pond

		Fe	Mn	Cu	Zn	Pb	Cd	
Sample	Denotation	←		Concentrations (μg g^{-1})		→		Ni
Sediment	TPS	60237	1398 ±74 ±851	33.1 ±9	332 ±78	135 ±2	0.2 ±0.01	23 ±4.8
Tilapia fish	TPF	1833 ±166	61.7 ±7	10.6 ±0.9	69.7 ±9	7.9 ±0.8	BDL*	1.28 ±0.3

*BDL=Below Detection Limit





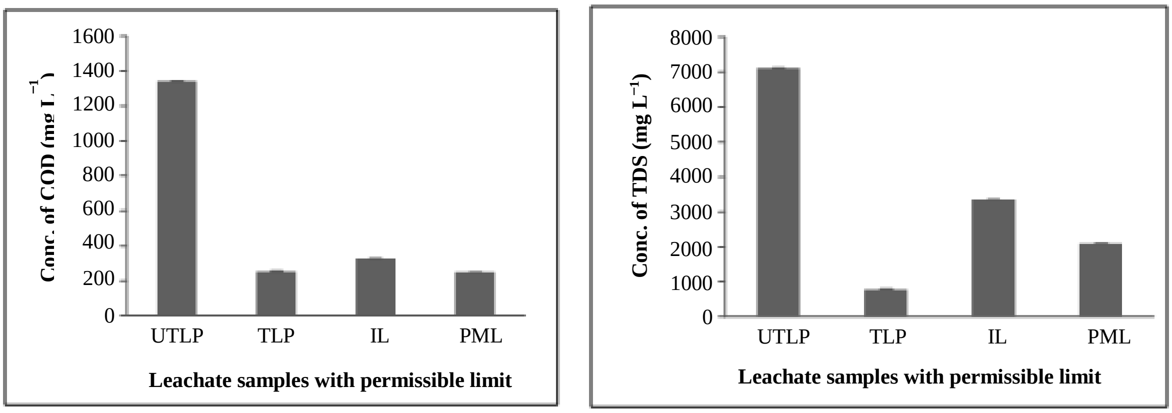


Fig. 8: Concentration of DO, BOD, COD and TDS in different leachate samples

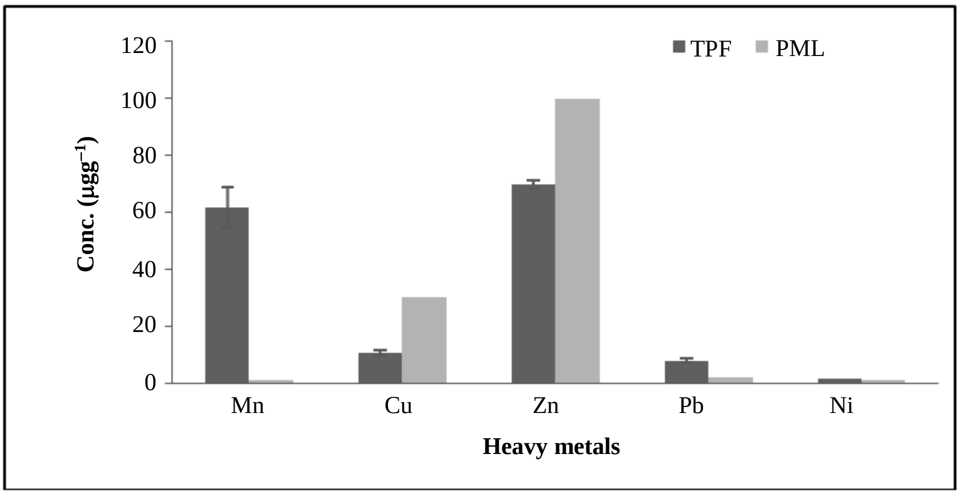


Fig. 9: Heavy metal accumulation in fish from treated leachate pond with their permissible limits

Table 5: Air quality monitored data summarized at the project locations

Parameters	Unit	Concentration at Monitoring Site	Bangladesh Standard*	Duration (hours)	Weather Condition	Method of Analysis
SPM	µg m^{-3}	163.4	200	8	Sunny	Gravimetric
PM2.5	µg m^{-3}	39.2	65	24	Gravimetric	
PM10	µg m^{-3}	145.8	150	24	Gravimetric	
SO_2	µg m^{-3}	18.39	365	24	West- Geake Jacob	
NOX	µg m^{-3}	25.7	100	Annual	Hochheiser and	
CO	ppm	2	9	8	CO Meter	

Note: *The Bangladesh National Ambient Air Quality Standards have been taken from the Environmental Conservation Rules, 1997 which was amended on 19th July 2005 vide S.R.O. No. 220-Law/2005

The Fe accumulation in fish (TPF) collected from treated pond is recorded high (1833 µg g^{-1}) that exceeded the permissible limit (100 µg g^{-1}) according to WHO (1989). It might be due to the high concentration of Fe in sediment of treated pond (60237 µg g^{-1}). In normal metabolism, fish may uptake heavy metals from water, food or sediment (Irwandi and Farida, 2009). The Mn value in fish sample collected from the treated pond showed higher accumulation of Mn that exceeded the permissible limit (1 µg g^{-1}; WHO, 1989; Fig. 9). It might be due to the high concentration of Mn in sediment sample in the same pond. The Cu and Zn are regulated by physiological mechanisms in most organisms. The accumulation of Cu and Zn by the Tilapia fish collected from treated pond, not exceeded the recommended limit (30 µg g^{-1} for Cu and 100 µg g^{-1} for Zn; WHO, 1989). The accumulation of Pb in the studied fish sample was found high (7.9 µg g^{-1}) that exceeded the allowable limit

(2 µg g^{-1}; WHO, 1989; FAO/WHO, 2010). Though the Pb concentration in treated leachate is below the detection level, the high accumulation of Pb in fish sample might be due to the presence of high concentration of Pb in the sediment (135 µg g^{-1}). The Cd concentrations in leachate fish sample from treated pond is below the detection limit but in sediment sample it is 0.2 µg g^{-1} (Table 4). The toxicity of Ni to aquatic life has varied significantly with organism species, pH and water hardness (Birge and Black, 1980). The accumulation of Ni in Tilapia fish is 1.28 µg g^{-1} higher than the recommended limit (1 µg g^{-1}; WHO, 1989). High concentration of Ni in Tilapia fish may reflects the substantial amount of Ni accumulation from sediment through food chain, although this finding needs thorough investigation.

Ambient Air Quality and Health Risk Analysis

Ambient air quality data at the project site measured to verify the current quality of air at Matuail Lndfill site of Jatrabari Dhaka. The aim is to identify the baseline air quality data. The main air pollutants in our country are Nitrogen Oxides (NOx), sulphur dioxide (SO2), Suspended Particulates Matter (SPM), PM10 (particulate matter with diameter of 10 microns or smaller), PM2.5 (particulate matter with diameter of 2.5 microns or smaller) and carbon monoxide (CO). Landfills are one of the major sources of these pollutants. The air quality testing was performed in and around the landfills and the laboratory test result for different measured locations are given in the Table 5. Filter and each chemical were measured before testing. Results of the air quality monitored at the project location have been showed in below:

SPM: Atmospheric particulate matter, also known as Particulate Matter (PM) or particulates or Suspended Particulate Matter (SPM) are microscopic solid or liquid matter suspended in Earth's atmosphere. The term aerosol commonly refers to the particulate/air mixture, as opposed to the particulate matter alone. Sources of particulate matter can be natural or anthropogenic. They have impacts on climate and precipitation that adversely affect human health. The above table shows that, for all the locations, SPM values did not exceed the national standard limits.

PM2.5: PM2.5 are 2.5 micrometers in diameter or smaller and can only be seen with an electron microscope. Fine particles are produced from all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes. The test results showed that all the value was within the national standard limits.

PM10: Particle pollution, also called particulate matter or PM, is a mixture of solids and liquid droplets floating in the air. Some particles are released directly from a specific source, while others form in complicated chemical reactions in the atmosphere. PM10 are 2.5 to 10 micrometers in diameter. Sources include crushing or grinding operations and dust stirred up by vehicles on roads. The test results showed that all the value was within the national standard.

SOx: Sulfur oxides (SOx) are compounds of sulfur and oxygen molecules. Sulfur dioxide (SO_2) is the predominant form found in the lower atmosphere. It is a colorless gas that can be detected by taste and smell in the range of 1,000 to 3,000 micrograms per cubic meter (µg m^3). From the test results it can be said that, for all the locations, the value was within the national standard.

NOx: In atmospheric chemistry, NO*x* is a generic term for the nitrogen oxides that are most relevant for air pollution, namely nitric oxide (NO) and nitrogen dioxide (NO_2). These gases contribute to the formation of smog and acid rain, as well as tropospheric ozone. The test results above showed that, the value did not exceed the national standard. CO: Carbon monoxide is a gas and is found in air. High levels of carbon monoxide are poisonous to humans and, unfortunately, it cannot be detected by humans as it has no taste or smell and cannot be seen. The main sources of additional carbon monoxide are motor vehicle exhaust and some industrial activities, such as making steel. Tobacco smoke is one of the main indoor sources of carbon monoxide. The above table showed that, for all the locations, CO was within the national standard limits.

Several human health risk assessments have been conducted to evaluate potential air emissions and these studies included assessments of potential risks to human health that could result from the air transport of facility emissions to residential locations in and around Matuail Landfill site. Risks to residents were evaluated assuming that a person would be exposed for 24 hours per day, 350 days per year, for several decades. All of the health risk assessments showed that facility emissions do not pose risks to residents in and around landfill site. The risk assessment results were consistently many times lower than standard benchmark risk levels for both non-cancer and cancer health effects. Overall, the risk assessments demonstrated that potential air emissions from the Matuail Landfill site did not pose public health risks.

Conclusion

The results showed that the soil of dumping and abandoned landfill area contained significant amount of heavy metals and their concentrations were found in the order of Zn>Pb>Cu>Ni>Cd, where Pb, Cu and Zn exceeded the maximum permissible limits. The surrounded agricultural area of the landfill site contains lower heavy metal concentrations than both dumping and abandoned areas. The dumping area also contains high organic matter and nutrient that may be due to the abundance of decomposed organic waste. Except Pb and Zn, the heavy metal concentrations of plant in entire areas of the landfill sites were below the level of toxicity. However, the nutrient concentrations of plant were present at satisfactory level. The concentrations of TDS, BOD and COD in untreated leachate pond was found higher than the DoE recommended inland surface water standard but in treated pond the values of TDS, BOD and COD were within the permissible limit. The Mn, Cu, Pb, Zn, Cd and Ni in leachate samples did not show contamination as it was found below the maximum permissible limit. The analysis revealed that the quality of treated leachate sample was succeeded to satisfy the inland surface water quality standard of Bangladesh. The fish and sediment samples collected from the treated leachate pond contained significant amount of heavy metals. The accumulations of Fe, Mn, Pb and Ni in fish sample were above the permissible limits (WHO, 1989; FAO/WHO, 2010). The soil, plant, leachate and fish samples collected from the landfill site are rich in both nutrient and some heavy metal concentrations.

From June 30, 2018 and ended on July 2, 2018, tests were conducted to determine the composition of landfill gases, the presence of chemical compounds in the ambient air around the facility and whether off-site subsurface migration of landfill gas was occurring. The study results showed that the Matuail landfill surrounding sites did not have an adverse effect and the main air pollutants in Dhaka City such as NOx, SO_2, SPM, PM10, PM2.5 and CO contents is also within national standard limit. All of the health risk assessments showed that facility emissions do not pose risks to residents in and around Matuail landfill surroundings. The risk assessment results were consistently lower than standard benchmark risk levels for both non-cancer and cancer health effects. Overall, the risk assessments demonstrated that potential air emissions from the Matuail Landfill site did not pose public health risks. If the dumping site is properly managed by segregating the waste according to their source, then this waste could be used as compost. Though dumping waste may cause adverse impact on environment, we cannot avoid this because developing countries like Bangladesh landfilling is the only way of waste disposal. However, by maintaining disposal sites with controlled placement and proper treatment of the waste may reduce the adverse impact on agri-environmental eco-systems. In addition, furthermore investigation is needed to further understand the role of poor air quality plays on health and disease and support development of more sustainable and integrated air quality management strategies.

Author's Contributions

Md. Faruque Hossain: Research plan, sampling, laboratory experiments, supervision, statistical analysis, interpretation and manuscript writing for publication.

ASM Maksud Kamal: Financial support, research supervision, statistical analysis and manuscript review.

Abdul Halim Farhad Sikder: Field sampling, laboratory experiments and analysis.

Zakia Parveen: Research plan, supervision and manuscript review.

Declaration of Conflicting Interests

The authors declare that there is no conflict of interest.

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