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Research Article

Deterioration of Soil Chemical Properties due to Unmanaged Solid Waste Dumping Station in Barishal, Bangladesh

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Abstract

Soils are life as they provide the best medium for plant growth as well as they are the habitats for different kinds of insects and other soil microorganisms. They act as the filtering system for the surface water, carbon sequester. The soils are polluted because of unmanaged solid waste dumping stations (landfills). Different kinds of solid wastes such as municipal wastes, medical wastes and sometimes the industrial wastes are dumped in the landfilling stations. The wastes can be entered into the soil as leachate. And, thus the soil resource can be polluted as the consequence. The research study has revealed the effects of the waste dumping station of Barishal on the chemical properties of soils. Soils of several agricultural plots surrounding the "Moylakhola" waste dumping station are influenced as the chemical properties (pH, ORP, EC, salt, organic matter and some other nutrients such as nitrogen (N), potassium (K) and sulfur (S)) of the soils are significantly altered. In this study, it is found that the deterioration of the chemical properties of the agricultural soils is increasing when the sampling point is getting closer to the solid waste dumping station. Several chemical properties are correlated to the physical properties of the soil as well. Further research is needed to examine the influences of the open and unmanaged disposal system of solid wastes based on the contamination due to heavy metals and persistent organic pollutants.

Keywords: Soil Chemical Properties; Soil Pollution; Solid Waste Disposal; Waste Dumping Station; Unmanaged Waste Disposal

Introduction

Soil pollution is an important issue throughout the world. The properties of soil are changed because of different kinds of phenomena such as human settlements, small industries and commercial activities [1]. Normally, the people of the Barishal City dispose of solid wastes based on the landfilling method. But if the landfilling is not handled in a managed way, different kinds of toxicants can be entered into the soil body as the leachate. There are some harmful impacts of the contamination from the municipal solid waste landfill on the underlying soil as well [2]. The generation of a huge amount of solid wastes can be occurred because of population growth and the economic development of a specific location [3]. Different kind of wastes such as household, industrial, biomedical waste are dumped in the one and only solid waste dumping station of the Barishal city and the local name of the dumping station is "Moylakhola". I have visited the site many times and talked to the local people regarding the impact of the disposal of solid wastes including biomedical wastes on the deterioration of the soil quality. Eventually, the chemical properties such as pH, ORP, EC, salt [4] etc of soils are influenced by waste materials. The local people use the dumped organic materials for the agricultural perspective. They mix the organic materials in the soil for the production of different vegetables. Even, the atmosphere of the region is full of different particulate materials. The surrounding environment including soil is also impacted because of the dry and wet deposition of the particles [5]. There is an incinerator in the corner of the dumping station but that is not effective enough. Different liquids such as liquid pathological and chemical wastes are not managed in a proper way. The authors of the paper intend to highlight the chemical characteristics of the soils of different agricultural plots surrounding the waste dumping station in Barishal city as well as the impact of the unmanaged waste dumping activities on the daily life of the individuals of the study area.

Objectives

The study was conducted based on two objectives:

1. Assessment of the chemical properties of the agricultural soils surrounding the unmanaged solid waste dumping station (Moylakhola), Barishal.

2. To figure out the impacts of the landfilling station on the surrounding vegetations.

Materials and Methods

The primary and secondary data for the study were used for the study. Different soil samples were collected from the agricultural plots surrounding the waste dumping station. The samples were analyzed by using different apparatus in the laboratory of Soil Resource Development Institute, Barishal, Bangladesh. And some secondary data were collected from different sources.

Study area

The one and only solid waste dumping station of Barishal City was selected for the study. The dumping station is situated at North Kaunia in Barishal city. The dumping station is located at 22°43′42″ N Latitude and 90°22′3″ E Longitude and a canal named Shapania flows from over there.

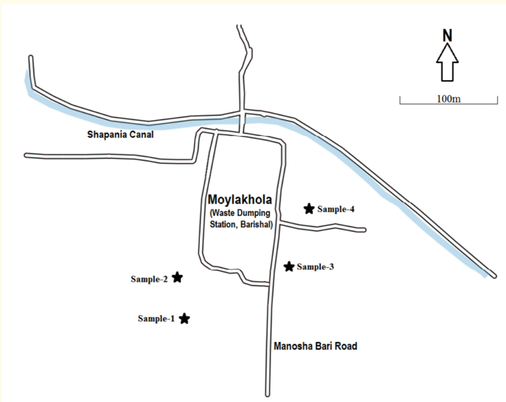

Figure 1: The map of the waste dumping station (Moylakhola), Barishal, Bangladesh.

Figure 2: The solid waste dumping station (Moylakhola), Barishal, Bangladesh.

Four agricultural plots surrounding the solid waste dumping station were selected for collecting the soil samples.

Serial No.	Sample No.	Latitude	Longitude
1	Sample-1	22°43′35″ N	90°21′60″ E
2	Sample-2	22°43′38″ N	90°21′59″ E
3	Sample-3	22°43′39″ N	90°22′05″ E
4	Sample-4	22°43′41″ N	90°22′06″ E

Table 1: GPS reading of the sampling points (Latitude and Longitude).

Climatically, the area falls in the tropical monsoon zone having 3 seasons: summers, winters and the rainy seasons. The rainy season starts in May and ends in August. About 88% of the rainfall occurs in this time. The winter season starts from November and ends on February. March and April are considered as the Summer season. The air is very much warmer and the humidity level is the lowest in this season. The lowest average temperature is 12°C (in December and January) and the highest temperature is about 36.1°C (in December). The average rainfall is 95mm (November to February), 387 mm (March to May) and 1666mm (June to October).

Soil Sampling, preparation, and preservations

The soil samples were collected from four different agricultural plots surrounding the waste dumping station on 1st December 2018. All of the organic matters and weeds were removed from the surface soil before doing the sampling. A spade was used for soil sampling. About 1kg of soil sample was taken from every agricultural plot of the study area. The soils were sampled from the plow layer or topsoil (up to 15 cm) of the agricultural lands of the study area. The soil samples were collected in the polyethylene bags including proper labeling.

In the laboratory, all of the collected soil samples were spread on separate trays. The samples were dried in air. The large soil aggregates were broken down gently using a wooden mortar and finally, every sample is passed through a 2mm sieve. The sieved soil samples were preserved for farther analysis in plastic containers in a cool and dry place in the laboratory.

Measurements of pH, EC, ORP, Salt

20 gm of soil was weighted and taken in a 100ml beaker. 50 ml distilled water was added in the beaker. That was stirred for about 30 minutes. Thus, the suspension of the soil was prepared. In the meantime, the pH meter was adjusted with the buffer solutions (pH 4 and 7).

The probe of the pH meter was used in the measurement of the pH values of the soil samples. Thus the EC values of the samples were measured from the soil extract using the probe of the EC meter where the ratio of soil and distilled water was 1:2.5. The values of the oxidation-reduction potential of the soil samples were measured using the ORP probe. And, the salt contents of the soil samples were also measured using the probe of salinity measurement.

Measurement of organic matter

Wet oxidation method (Walkley and Black Oxidation Method) is applied to measure the organic matter contents of the soil samples. The principle that organic carbon compounds are highly reducing substances is employed in the determination of organic carbon. Chromic acid is a suitable oxidizing agent for determining soil organic carbon. The excess chromic acid left after the oxidation of organic carbon may be determined volumetrically with standard ferrous sulfate solution, and the quantity of substance oxidized is calculated from the amount of chromic acid reduced [6].

Measurement of total nitrogen

The Kjeldahl method is employed for the determination of the total nitrogen content of the soil samples. The digestion is usually performed by heat on the samples with H_2SO_4 containing substance which oxidize the organic matter in the samples and concomitant conversion of the organic nitrogen to ammonium sulfate, the substances generally favored being salts such as K_2SO_4 or Na_2SO_4 which increases the temperature of digestion and catalysts such as Cu or Se, which increase the rate of oxidation of organic matter by H_2SO_4 [6].

Measurement of potassium

The content of total potassium of the soil samples is determined by Flame Photometry method. The extract is atomized in the flame where the atoms of the element are excited, emitting radiations of characteristics wavelength. The radiation emitted by the K atoms is passed through the filter which falls on photocell emitting electrons i.e electric current which is measured on galvanometer of a flame photometer. The electric current generated is proportional to the concentration of K into the extract [6].

Measurement of sulfur

The determination of sulfur of the soil samples was determined using a spectrophotometer. Readily soluble and adsorbed sulfates are extracted with a monocalcium phosphate $Ca(H_2PO_4)_2$ solution containing 500 parts per million of phosphorus. The $BaCl_2$ should be added to the sulfate solution in the solid state as crystals of definite size, and not as solution. The size of the crystals will determine the rate of solution which in turn determines the rate of reaction with sulfate. Thus, with a standard shaking procedure, it is possible to obtain reproducible results more easily than by adding BaCl2 solution. The optimum pH should be maintained to reduce the effect of the other ions and a stabilizer is added to keep the precipitate in suspension [6].

Result and Discussion

The results of different chemical properties (soil pH, soil temperature, electrical conductivity (EC), oxidation-reduction potential (ORP), salt contents, organic matter and some nutrient elements such as nitrogen (N), potassium (K) and sulfur (S) of the agricultural soils surrounding the waste dumping station (Moylakhola), Barishal are given below using different tables and graphs:

Sample No.	pH	Temperature (°C)	ORP (mV)	EC (mS/cm)	Salt (ppm)
Sample-1	7.46	26.9	177	0.892	444
Sample-2	7.49	27.1	138	1.555	772
Sample-3	6.91	26.8	158	1.344	671
Sample-4	6.70	26.1	153	1.291	645

Table 2: Data of the Laboratory Analysis of the Soil Samples of the Study Area.

Many studies also have examined relationships among elements (major and trace) and other soil properties (clay content, cation exchange capacity, pH, soil texture) in non-contaminated soils [7].

Parameters	N	Minimum	Maximum	Mean	Std. Deviation
pH	4	6.70	7.49	7.140	.39640
Temperature (°C)	4	26.10	27.10	2.673	.43493
ORP (mV)	4	138.00	177.00	156.5	16.093
EC (mS/cm)	4	.892	1.555	1.271	.27690
Salt (ppm)	4	444	772	633.0	137.39

Table 3: Descriptive Statistics of the chemical properties of the soil samples.

Soil pH

It was observed from the pH value that soil samples were varying from 6.70 to 7.49. The optimum pH ranges from 5.5 to 7 (from the pH scale). But, there are 2 soil samples that satisfy the optimum level of pH. But, the pH of sample-1 is more than 7 and that is 7.46 and the soil is slightly alkaline in nature. And the pH value of soil sample-2 is 7.49 and that is out of the range of the optimum level of pH for the agricultural point of view. The pH value of the soils of the region was 7 according to the Soil Resource Development Institute, Barishal, Bangladesh. The parameter is very much important as it directly affects the availability of plant nutrients in the soil. Soil microorganisms are hindered by high acidity, and most agricultural crops do best with mineral soils of pH 6.5. Most of the microorganisms must have an optimum range of soil pH for the function and survival. The most important effect of pH in the soil is on ion solubility, which in turn affects microbial and plant growth. A pH range of 6.0 to 6.8 is ideal for many crops as it coincides with optimum solubility of the most important plant nutrients. There is a great relationship between the nutrient elements (major and trace) and the soil pH [7]. Some minor elements (e.g. iron) and most heavy metals are more soluble at lower pH.

Electrical conductivity (EC)

EC is correlated with some other soil properties such as the level of production of the crop, cation exchange capacity (CEC), soil texture, drainage conditions of the soil, the level of organic matter (OM), salinity. Even, the characteristics of the subsoil are also influenced by electrical conductivity. The EC value 1 is perfect for plant growth. But when the EC is less than 1 or more than 1, the plant growth can be affected badly. The plant growth will be stunted and ultimately the plant health will not be developed. As the EC of the soil samples is more or less 1, the plant growth of the study area must be affected. The EC value of the soils of the region was 0,8 mS/cm according to the Soil Resource Development Institute, Barishal, Bangladesh. Soil EC provides a measure of the within-field soil differences associated with topsoil thickness which is directly correlated with root-zone suitability for crop growth and yield [8].

Salt content

The salinity of the extract solution of the soil is an estimate of the amount of total dissolved salt within the soil solution and is typically expressed as mg/L or parts per million (ppm) [4,9].

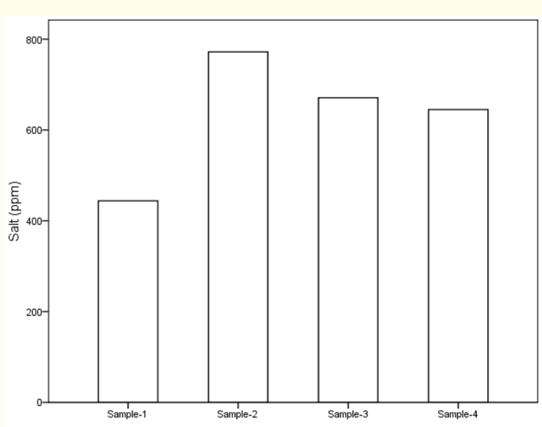

Figure 3: The graphical representation of the salt content of the soil samples.

The salt concentration of the soil samples varies between 444 ppm and 772 ppm. The salt content of the samples is increasing when the sampling point is getting closer to the waste dumping station. An increasing of salt concentration reduces the osmotic potential resulting in stunted plant growth [10].

		EC	Salt
EC	Pearson Correlation	1	1.000**
	Sig. (2-tailed)		.000
	N	4	4
Salt	Pearson Correlation	1.000**	1
	Sig. (2-tailed)	.000	
	N	4	4
**. Correlation is significant at the 0.01 level (2-tailed).			

Table 4: Correlation (Pearson) between EC and Salt.

There is a strong relationship between the electrical conductivity and the salinity of the soil. And, that is proved by applying the Pearson Correlation to the data of the EC and salt content. The correlation is significant at the 0.01 level.

Oxidation-reduction potential

The oxidation-reduction potential (ORP) is an important chemical parameter of soil. Healthy soil relies on water, oxygen, air and a balanced supply of different nutrients. Chemical reactions in the soil may alter the physical structure of the available nutrients. The oxygen exchanges are directly involved with the oxidation-reduction process.

The process takes place between the water content and the inorganic materials in the soil. Thus, the supply of available nutrients is directly related to the ORP of a specific soil. Eventually, oxidation and reduction processes in soil involve the exchange of electrons and that is taking place between the soil materials.

		pH	ORP
pH	Pearson Correlation	1	.067
	Sig. (2-tailed)		.933
	N	4	4
ORP	Pearson Correlation	.067	1
	Sig. (2-tailed)	.933	
	N	4	4

Table 5: Correlation (Pearson) between pH and ORP.

The optimum value of ORP ranges from +400 to +700 mV. In our soil samples, the ORP values do not satisfy the optimum range of

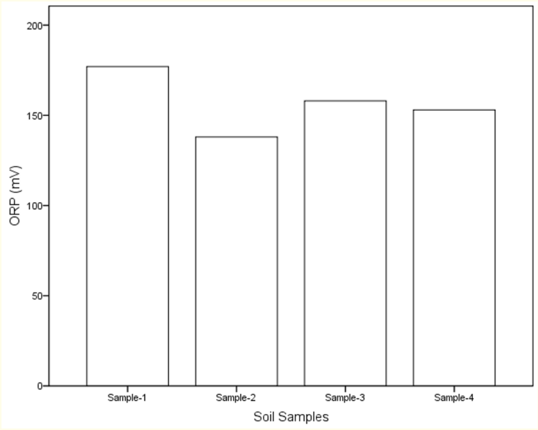

Figure 4: The graphical representation of the ORP values of the soil samples.

fertile soil. The adverse effect of dumping different solid wastes can be visualized regarding this. The lowest ORP value is only 138 mV for the Sample-2. On the other hand, the highest ORP value is 177 mV for the sample-1. The level of water content is very much low in the study area. So, the ORP goes down and there is an adverse effect of the unmanaged disposal of solid wastes in the Moylakhola Dumping Station, Barishal.

Parameters	N	Minimum	Maximum	Mean	Std. Deviation
Organic Matter, %	4	2.43	3.95	2.8675	0.7243
Nitrogen (N), %	4	0.122	0.198	0.1435	0.0364
Potassium (K), meq/100g	4	0.32	3.15	1.6175	1.5053
Sulfer (S), µg/g	4	8.0	23.5	16.650	7.6683

Table 6: Descriptive Statistics of some other chemical properties (OM, N, K, S) of the soil samples.

The organic matter content, total nitrogen, potassium, and sulfur of the soils were 2.58%, 0.106%, 0.23 meq/100g, 47.80 µg/g according to the Soil Resource Development Institute, Barishal. But, the chemical properties of the soils are changed negatively because of the unmanaged solid waste dumping station.

Eventually, among the soil samples, agricultural soil (sample-2) of 22°43′38″ N and 90°21′59″ E is highly affected because of the unmanaged disposal of solid waste in the waste dumping station.

Recommendations

Different kinds of household waste, biomedical waste and sometimes industrial waste are dumped in the one and only waste dumping station (Moylakhola) in Barishal city. But the management system is not good at all. There is no well-managed system of the disposal of the wastes. The transports of Barishal city corporation (BCC) transport the waste from different locations throughout the Barishal city and dumped in the Moylakhola (dumping station) without considering any treatment process. But, this can be a reason of environmental hazard in the long run. The individuals of the area of the Moylakhola region are already suffering from different soil and airborne diseases because of the unmanaged disposal systems. There are some great impacts of the unmanaged disposal of different solid wastes on the daily life of the individuals [11].

There are some recommendations that can be considered to overcome the impact of the unmanaged waste dumping system on the agricultural soils as well as the livelihood of the people of the study area. The recommendations are as follows:

1. The sanitary landfilling can be considered to the disposal of the solid wastes.
2. The organic wastes can be converted into different composts that can be used for agricultural lands. Composts can be acted as the soil conditioner as well and can also be used as the base for fertilizers.
3. Vermicompost can also be prepared and manufactured. Thus, that will be economically significant.
4. Thermal treatment techniques of the municipal solid wastes should be applied as the treatment of the wastes.
5. Incineration is an important waste management system. It is a treatment process in which the combustion of different organic materials contained in the waste material involves. The temperature for the incineration ranges from 850°C to 980°C. The solid wastes are converted into the flue gas, ash as well as heat. So, this process can be considered for the management of the wastes of the Moylakhola waste dumping station, Barishal.
6. Phytoremediation can also be a solution to the soil pollution that is caused by the disposal of solid waste in the waste dumping station, Barishal (Moylakhola). Different heavy metal contaminated soil can be remediated using the method.

There are 3 types of phytoremediation:

- Phytovolatilization
- Phytostabilization
- Phytoextraction

The authority should apply the three methods to figure out the effective one for the waste dumping station of the Barishal city (Moylakhola).

The transportation of the solid wastes from different areas of the Barishal city to the waste dumping station, Moylakhola should occur in a managed way. So, the selection of the route by which the waste will be transported is an important phenomenon.

Conclusion

The impact of the waste dumping station of Barishal City is not a recent phenomenon. The people of the study area has been experiencing a different kind of problems that are directly or indirectly related to soil pollution because of the unmanaged disposal system of the waste dumping station of Barishal. The chemical properties of the soil of the surrounding area of the waste dumping station (Moylakhola), Barishal is directly influenced because of the unmanaged disposal of the wastes. Even, there are some chemical properties such as oxidation-reduction potential, pH etc are also related to the physical properties of the soil such as soil structure. Thus, the physical and chemical properties are affected because of the present situation of the waste disposal system. Even, different soil-borne diseases are observed in the study area (interviews of the individuals of the study area). Fungal, plasmodiophorid, oomycete, and bacterial pathogens, as well as viruses and plant parasitic nematodes, may all cause soil-borne diseases. The vegetables that are cultivated in the study area can also be highly contaminated with different inorganic and organic pollutants as well as with heavy metals. The pollutants can be transferred into the food chain while the contaminants are taken up by the plants. Sometimes, the outlook of the vegetations is good enough to look at. But, the chemistry of the crops is not at the satisfactory level at all. Eventually, it is a hazard to human health of the region. Even, the biomedical waste should be managed in a managed way. Especially, the liquid biomedical waste should be treated using the Effluent Treatment Plant (ETP) before discharging the waste into the environment.

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Volume 3 Issue 4 April 2019