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Assessment of physico - chemical properties and heavy metal concentration in soil of municipal solid waste dump yards in Trivandrum

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ABSTRACT

Disposal of municipal solid waste is a major problem all over the world. Due to lack of successful waste management system municipal solid waste are dumped at open places without proper segregation. Analysis of the changes in soil quality due to the dumping of municipal solid waste was done in this study. Top soil samples were collected from three Municipal waste dumping areas in Thiruvananthapuram City *viz*. Chala, Palayam and Manacaud. Control samples were also collected from places about 100 m away from the sites. The Physico- chemical properties of soil such as pH, Electrical Conductivity, Moisture content, Organic matter content, Available potassium, Phosphorus and heavy metals such as Zinc, Copper, Nickel, Cadmium, Lead and Manganese were analyzed. The physico-chemical properties were found altered and concentration of heavy metals of the soils collected from waste dumping areas were found higher when compared to the control samples. The results showed that indiscriminate dumping of municipal solid waste causes alteration of soil properties and heavy metal pollution in soil.

KEYWORDS: Heavy metals, municipal solid waste, physico- chemical properties, soil.

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INTRODUCTION

Soil is a valuable natural resource for the survival of organisms[1] and hence needs to be protected. Lack of successful waste management systems forces people to dump the garbage in nearby road side open places having less human activity. Indiscriminate dumping of wastes causes soil pollution and the leachate from it contaminates surface and ground water supplies[2]. The solid waste act as an external force affecting the physico-chemical characteristics of soil which in turn leading to poor production of vegetation[3]. The present study is a preliminary work on the assessment of changes in soil physico-chemical properties and heavy metal concentration in soil contaminated by dumping of Municipal solid wastes.

MATERIALS AND METHODS

The collection and analysis of soil samples were done as per standard methods. Top soil samples were collected from three road side waste dumping areas in Thiruvananthapuram City viz. Chala (Site I), Palayam (Site II) and Manacaud (Site III). Control samples were also collected from places about 100 m away from the dumpsites. The soil samples were dried naturally by spreading it on a tray. The samples were crushed mechanically and sieved using 2mm sieve. The sieved samples were stored in labeled polythene bags for physico chemical analysis using standard methods.

pH was measured using a glass electrode pH meter (ELICO, LI 614). The conductivity was measured using a conductivity meter (Systronics, 306). Organic carbon content was analyzed by the dichromate oxidation and titration with ferrous ammonium sulphate method described by McLeod (1973)[4]. Available phosphorus in soil was determined using Bray and Kurtz method (1945)[5]. Moisture content was determined by oven dry method. The heavy metals in soil were analyzed using air acetylene flame atomic absorption spectrophotometer (AAS) (Perkin Elmer PinAAcle 500) after triacid method of soil digestion.

RESULTS AND DISCUSSION

Physico-chemical properties of soil samples were shown in table 1 and heavy metal concentrations were shown in table 2.

pH

The pH is a basic criterion for identification of the chemical nature of the soil. It is the measure of hydrogen ion activity and depends on relative amounts of adsorbed hydrogen and metallic ions in the soil. The pH of natural soil is in the range 7 - 8.5 and the variation is due to biological activity, temperature, disposal of municipal waste *etc*[6].

In the present study pH of the dumpsites were found to be slightly acidic (5.9-6.5) in nature compared to that of control sites (7.3- 8.1). The maximum acidity was found in site II (Palayam) followed by Site III (Manacaud) and Site I (Chala). Acidic pH in dumpsites was due to the decomposition of organic matter leading to the formation of organic acids[7].

Electrical Conductivity (EC)

Conductivity is a measure of the current carrying capacity affected by the soluble salts present in the soil. In the present study, EC values of dumpsites were higher than that of corresponding controls. Studies by Siva Praveena and Rao (2016)[7] also showed similar results. The maximum EC was found in site II (Palayam) followed by Site I (Chala) and Site III (Manacaud). According to Oberlin (2013)[8] the higher EC values in dump sites is due to the decomposition of organic matter present in the Municipal Solid Waste.

Available Soil Potassium

Available potassium obtained was ranged from 180-284mg/Kg in dumpsite soil which is significantly higher than that in the corresponding control soil (140-173 mg/Kg). Due to degradation of solid waste, potassium content in soil increases[9,10].

Available Soil Phosphorus

Available phosphorus in soil ranged between 4.8 and 10.5mg/kg in dumpsite soil and 2-3.2 mg/kg in control soil. High values of available phosphorus showed the presence of the constituents of domestic wastes such as soaps and detergents in the landfill[11].

Organic Matter

Soil organic matter possesses a natural magnetism to water and it prevents the pollutants reaching ground water[6].The organic matter present in the dumpsite soil were found to be higher (3.15-4.1) than that of corresponding control soil (1.64-1.82). The highest concentration of organic matter was

found in site II (Palayam) followed by Site III (Manacaud) and Site I (Chala). The presence of organic matter is mainly from bio degradable materials in the solid waste and hence it is higher in soil where domestic waste is dumped. Studies of Saritha *et al.*, (2014)[12] also showed that organic matter in dump yard soils were high making the soil more productive for vegetation.

Moisture Content

The moisture content (MC) of the dumpsite samples were found to be higher (25.14- 27.14) than that of control samples (20.12 -21.52). This agreed with the findings of Zhang *et al*. (2007)[13]. High organic matter content in the wastes dump favors increased moisture content and water holding capacity[14]. Sarita *et al*., (2014)[12] also reported very high values (25%) of moisture content in waste soil and opined wetness depends largely on the porosity of soil.

Table No. 1: "Physico Chemical properties of Soil samples"

Parameters	**Site I**	**Control I**	**Site II**	**Control II**	**Site III**	**Control III**
pH	6.0 ± 0.13	7.3 ± 0.04	5.9 ± 0.02	8.1 ± 0.02	6.5 ± 0.05	7.8 ± 0.01
EC (mS/cm)	0.48 ± 0.04	0.25 ± 0.01	0.68 ± 0.12	0.33 ± 0.02	0.52 ± 0.01	0.28 ± 0.13
Available Potassium (ppm)	180 ± 2	140 ± 3	220 ± 5	150 ± 3	284 ± 3	173 ± 2
Available phosphorus (ppm)	4.80 ± 0.01	2 ± 0.02	8.72 ± 0.01	2.1 ± 0.03	10.5 ± 0.01	3.2 ± 0.05
Moisture Content	25.14 ± 0.02	20.12 ± 0.05	27.14±0.02	21.52±0.10	26.32± 0.10	20.32 ± 0.05
Organic Matter (%)	3.15 ± 0.07	1.64 ± 0.02	4.10 ± 0.05	1.82 ± 0.02	3.2 ± 0.02	1.72 ± 0.02

Table No. 2: "Concentration of Heavy Metals in soil ($mgKg^{-1}$)"

Heavy Metals	Control I	Site 1	Control II	Site II	Control III	Site III
Zn	12.2± 0.02	19.30 +0.15	10.25+ 0.01	22.34 + 0.1	8.22+ 0.03	30.42 +0.13
Cu	1.30 + 0.22	3.46 + 0.12	1.22+ 0.14	3.40 +0.27	1.32+ 0.13	5.34 + 0.32
Ni	5.25 + 0.12	7.72 + 0.40	3.4 + 0.40	10.01 + 0.02	3.50 + 0.02	10.78 + 0.06
Cd	*BDL	*BDL	*BDL	*BDL	*BDL	0.20 + 0.03
Pb	8.83 + 0.64	18.92 + 0.08	3.24+ 0.04	12.04 +0.32	5.54+ 0.02	18.22 + 0.50
Mn	4.20 + 0.32	12.20 + 0.03	4.24 + 0.34	16.03 +0.02	3.23+ 0.05	22.32 + 0.52

* BDL- Below detectable Limit

Heavy Metals

Metals are present in soil as a natural component or as a result of human activities, such as smelting of metalliferous ores, electroplating, fuel production, fertilizer and pesticides application, and generation of municipal waste[15,16]. Kitchen, ash, plastic, and industrial wastes are the primary sources of metals in municipal solid waste landfills[17].

Total metal content is important because it determines the size of the metal pool in the soil and thus the potential for metal uptake[18]. The soil samples were analyzed for total Zn, Cu, Ni, Cd, Pb and Mn (Table 2). Zn, Cu and Mn are essential elements and Ni, Cd and Pb are non-essential heavy metals.

Zinc

Zinc is an essential trace element for human health[19]. Many foodstuffs contain certain concentrations of Zn. The concentration of total Zinc at dumpsites ranged between 19.3 -22.34 mg/kg and at control samples ranged between 8.22- 12.2 mg/kg.

In the present study the concentration of total zinc found in dumpsite soils was higher than that obtained by Okeyode and Rufai (2011)[20]. Motor vehicle emission, smelting, scrap metal processing and application of sewage sludge may cause Zn accumulation in dumpsites[21].

Copper

The concentration of copper at the dumpsites ranged between 3.4 - 5.34 mg/kg and that at control soils ranged between 1.2 -1.32 mg/kg. Decomposition of biodegradable waste introduces metallic copper into soil[22].

Nickel

The concentration of Nickel at the dumpsites ranged between 7.72-10.78 mg/kg and that at control soils ranged between 3.4 – 5.25 mg/kg. Nickel deposition in the soil can be due to land fill, weathering of soil, *etc*[23].

Cadmium

Cadmium was present only in one sample obtained from dumpsite (Site III**)**. In all other samples it was at below detectable limit (BDL). Cadmium is a very toxic heavy metal which causes serious health problems in humans if ingested.

Lead

The concentration of total lead at the dumpsites ranged between 12.04 -18.92 mg/kg and that at control soils ranged between 3.24 - 8.83 mg/kg. The leachate from un-segregated lead battery in MSW is the reason for increased presence of lead in dumpsites[24].

Manganese

The concentration of Mn at the dumpsites ranged between 12.2 - 22.32 mg/kg and that at control soils ranged between 3.23 – 4.24 mg/kg. The highest concentration of manganese was found in Site III (Manacaud) followed by Site II (Palayam) and Site I (Chala).

Each dumpsite soil sample exhibited a high concentration in one or more heavy metals. According to Zahra *et al.* (2018)[25], the heavy metals found at contaminated sites are in the following order: lead (Pb)> zinc (Zn)> cadmium (Cd)> copper (Cu).

CONCLUSION

The soil samples collected from the dump sites showed significant variation in physico-chemical parameters and heavy metal concentration from that of control samples taken 100m away from dumpsites. Indiscriminate dumping of solid waste altered the soil properties and heavy metal

concentration. The toxic heavy metals may leach out to the nearby water sources and cause a threat to plants, animals and human being and cause biomagnification in the course of time. The study shows the need of segregation of toxic components from municipal solid waste before dumping in open places.

REFERENCES

1. Uma R.N., Prem Sudha, Murali K. Assessment of Soil Quality at Municipal Solid Waste Dump site in Coimbatore Tamilnadu, India. International Journal of Advanced Engineering Technology. 2016; 7(2); 1301-1307.
2. Sunil Srigirisetty, Thadivalasa Jayasri, Chitti Netaji. Open Dumping of Municipal Solid Waste-Impact on Ground Water and Soil. Internanional Journal of Current Engineering and Scientific Research (IJCESR). 2017; 4 (6); 26-33.
3. Christensen D., Drysdale D., Hansen K., Vanhille J., and Wolf A. Partnerships for development: Municipal solid waste management in Kasese, Uganda. Waste Management and Research. 2014; 32(11); 1063–1072.
4. McLeod S. Studies on wet oxidation procedures for the determination of organic carbon in soil. CSIRO Division of Soils Notes on Soil Techniques. 1973; 73-79.
5. Bray R.H. and Kurtz L.T. Determination of Total Organic and Available Forms of Phosphorus in Soils. Soil Science. 1945; 59; 39-45
6. Oyedele, D. J, Gasu, M.B., Awotoye, O.O. Changes in soil properties and plant uptake of heavy metals on selected municipal solid waste dump sites in Nigeria. African Journal of environmental science and Technology. 2008; 3(5); 107-115.
7. Siva Praveena G., Prasada Rao P.V.V. Impact of Leachate on Soil Properties in the Dumpsite (A Case study of Greater Visakhapatnam). International Journal of Engineering Research and General Science. 2016; 4 (1); 235-241.
8. Oberlin A.S.. Resource recovery potential: a case study of household waste in Kinondoni municipality, Dar es Salaam. Tansania Journal of Natural and Applied science. 2013; 4; 563-574.
9. Effiong G.S. and Libia. Mineral Fertilizers, Manufacture and Chemistry in the soil environment. Teaching Monograph, University of Uyo. Nigeria; 2003.
10. Eddy N.O., Odoemelem S.A. and Mbaba A. Elemental composition of soil in some dumpsites. Electronic J. Env., Agri., and food chemistry. 2006; (5) 3; 1349-1365.

11. Akinbile C.O, Ajibade F.O, Ofuafo O. Soil Quality Analysis for Dumpsite Environment in a University Community in Nigeria. Journal of Engineering and Engineering Technology (FUTAJEET) 2016;10 (2); 68-73.
12. Saritha V., Srikanth Vuppala N.V., Prashanthi K. and Ayesha Anjum. Soil Properties governed by Municipal Solid Waste – Contemporary and Enduring. Agriculture and Soil Sciences (LRJASS) 2014; 1 (4); 042-049.
13. Zhang S., Lovdahl L., Grip H., Jansson P., Tong Y. Modelling the effects of mulching and fallow cropping on water balance in the Chinese Loess Plateau. Soil and Tillage research. 2007; 93; 283-298.
14. Ibitoye A.A. Effects of municipal refuse dump on soil and water quality in Akure Metropolis, Journal of Applied Soil Science. 2001; 2; 16–24.
15. Wenzel W.W., Jockwer F. Accumulation of heavy metals in plants grown on mineralized soils of the Austrian Alps. Environ. Pollution. 1999;104: 145- 155.
16. Kabata-Pendias, A., Pendias, H. Trace elements in soils and plants. CRC Press; 2001.
17. Yu-Yang Long, Dong-Sheng Shen, Hong-Tao Wang, Wen-Jing Lu, Yan Zhao. Heavy metal source analysis in municipal solid waste (MSW): Case study on Cu and Zn. Journal of Hazardous Materials. 2011; 186;1082–1087.
18. Ibekwe A.M., Angle J.S., Chaney R.L., van Berkum, P. Sewage sludge and heavy metal effects on nodulation and nitrogen fixation of legumes. J. Environ. Qual. 1995; 24; 1199-1204.
19. Raymond A. Wuana and Felix E. Okieimen. Heavy Metals in Contaminated Soils: A Review of Sources, Chemistry, Risks and Best Available Strategies for Remediation. 2011. Article ID 402647 .20 pages | https://doi.org/10.5402/2011/402647.
20. Okeyode I.C. and Rufai A.A.. Determination of Elemental Composition of Soil Samples from some Selected Dumpsites in Abeokuta, Ogun State, Nigeria, using Atomic Absorption Spectrophotometer. International journal of Basic and Applied Sciences. 2001; 11(6); 55-70.
21. Steve Ellis and Tony Mellor. Soils and Environment. Routledge; 1995.
22. Dara S.S A textbook of environmental chemistry and pollution control. S. Chand & Company Ltd. Ram Nagar, New Delhi 110055;1993.
23. Knox, A.S.; Gamerdinger, A.P.; Adriano, D.C.; Kolka, R.K.; Kaplan, D.I. Sources and Practices Contributing to Soil Contamination. In: Bioremediation of Contaminated Soils, D.C. Adriano, J.-M. Bollag, W.T. Frankenberger, Jr., and R.C. Sims Eds. 1999; 37: 4.

24. Moturi M. C. Z., Rawat M. and Subramanian V. Distribution and Sequential Extraction of Heavy Metals in Solid Waste from the Industrial Belt of Delhi, India. Environment Monitoring and Assessment. 2004; 95(1-3): 185-199
25. Zahra Derakhshan Nejad., Myung Chae Jung., Ki-Hyun Kim. Remediation of soils contaminated with heavy metals with an emphasis on immobilization technology. Environ Geochem Health 2017; 40(3): 927-953.