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Physicochemical and Biological Properties of Land and Water Bodies Surrounding Major Dumpsites in Kolkata

Arkadeep Dutta [a], Anyeasha Dutta [b], Debapriya Nandi [c], Manua Banerjee [a,*], Haru K Das [a], Swarniv Chandra [d,e]

[a] Department of Earth Sciences and Remote Sensing, JIS University, Agarpara, Kolkata-700109, India

[b] Govind Ballabh Pant Hospital, New Delhi, Delhi-110002, India

[c] Modern Institute of Engineering & Technology, Bandel, India, W.B.712123, India

[d] Department of Physics, Govt. General Degree College, Kushmandi, D. Dinajpur-733121, India

[e] Institute of Natural Sciences and Applied Technology, Kolkata-700032

* Corresponding Authors: manua@jisuniversity.ac.in

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Abstract: In this paper we have investigated the data acquired from the analysis of the soil and water samples from and around the dump sites in Kolkata and North 24 Paragana district of West Bengal where the population density is extremely high. The treatment of disposal of municipal solid wastes and waste water has been inadequate to negligible in these areas and as a result the quality of soil and water bodies is subject to deterioration. We have made use of GPS enabled Satellite acquired images and its associated softwares to identify and demarcate the areas that come under the direct impact of the dumping sites, and which ultimately are the areas prone to diseases and degradation in the coming years. The pH, salinity, Total Dissolved Solvents and oxidation reduction potential has been investigated for the basic characterization of the samples. An estimate of heavy metals has also been made. Estimation of salts and oxides from the various sediments and soil samples were acquired. Identification of bacteria, under the purview of biological studies and the dependence of their growth on physiochemical parameters of the surrounding has portrayed an alarming result. Adjacent to these areas there are agricultural fields where leached water from the dumping site directly drain into and cause biomagnifications. Contamination of the ground water is also sizable. This research will help to control pollution and biological outbreaks as well as suggest areas where immediate care should be taken to set up environmental restoration. The findings of the paper will further enlighten the planning and designing of waste disposal in urban areas and assist in its policy making in urban areas and thereby improve the quality of life of the scavengers who are left to equate their survival with the garbage mounds.

Keywords: GIS, Dumpsite, Municipal solid waste, Legacy waste, Physio-chemical properties, Thermal properties, Soil and water pollution

1. Introduction

Over the past few centuries, there has been increase in exploration of natural resources and industrial activities. Forest cover has been depleted and there has been accumulation and toxic substances and heavy metals in soil and water bodies [1-3]. This has become more pronounced with the increase in population and unplanned urbanisation-law use has been extensive than ever. Water bodies and subsurface water have become unfit for use. Human activities and increased use of non-degradable products have made the situation graver than ever. Urban agglomerations worldwide bear the same brunt due to human activities [4-7]. We will not get into the unwanted redundancies that has been reported this far regarding pollution. Rather, we want to investigate the level of contamination of soil and water around us. For this purpose, we chose certain areas in and around Kolkata which are used by local authorities to dump municipal wastes. We have identified few dumpsites along the Sealdah-Lalgola railway tracks around which there are human settlements, both planned as well as slums. The procedure carried out in our investigation is elaborated in the next sections along with results. We mapped our dumpsites in Titagarh which has large scale land use for agricultural purposes near to dumpsite based on population and severely affected by such pollution. The method is discussed below.

Steps of preparation of population density map

1) Scan map of Titagarh municipality with ward boundary and ward wise population data (from 1981 onwards) were collected.
2) Using PCI Geomatica OrthoEngine, and Ground Control Points, scan map was georeferenced, then ward boundary digitized and populate with population data. After that we calculate the ward wise population density using this formula ;(individual word population / individual word area) then we compute this data into the attribute table and prepare the population density map of Titagarh municipality.

Interpretation of the map: In map generated, it was clearly seen that the Titagarh municipality area is highly populated. It clearly indicates that the amount generating waste is very high. Per day average 50-60 tons waste material produced in the area. The total population of this area is 116520 (as per 2011 census) that are much higher than earlier years. In this map we see that the word no 19 and 9 have maximum population density and ward no 20, 2, 4, 8, 18 have moderate population density and rest of wards are relatively lower denser. Therefore, a proper waste material management and ecology restoration is essential.

2. Collection

The soil and water samples were collected from the adjacent areas of dumpsite which are often used for human activities for Agricultural purposes and Pisciculture. In this paper (Table-1) the locations for the collection of samples along with the latitude and longitude and depth from the surface are given. We also provide some photographs of the sample-sites (Figures 1-10). The GIS data is also provided.

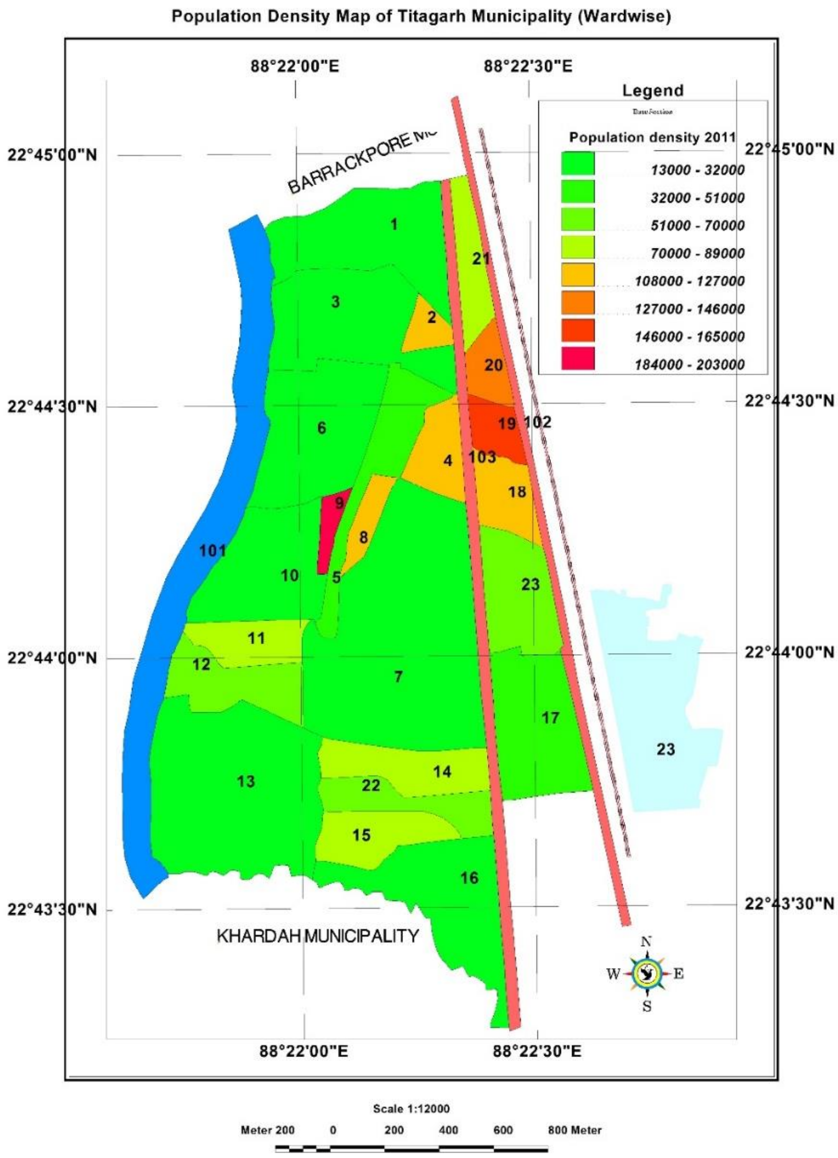

Figure 1. Population Density map of the area close to dumpsite of Titagarh Municipality

Table. 1 Water and Soil sample from Agarpara and Titagarh Waste Dumping Site

Sl No.	Type of Sample	Locality	Latitude	Longitude	Depth of Sample from surface	Description
1	Soil sample 1	Agarpara	22°40'40"	88°22'49"	33cm	Collected from waste dumping site
2	Soil sample 2	Titagarh	22°44'01"	88°22'36"	30cm	Collected from the waste dumping site
3	Water sample 1	Agarpara	22°40'45"	88°22'46"	Near Surface	Sample collected from leached water: flowing down a drain
4	Water sample 2	Titagarh	22°44'01"	88°22'35"	4ft	Welllocated approximately 25m from the waste site, used for cultivation, cleaning of domestic articles
5	Water sample 3	Titagarh	22°44'08"	88°22'41"	Surface	Collected near a 1st level lagoon, leached from the dumping site
6	Water sample 4	Titagarh	22°44'03"	88°22'40"	2ft	Well located approximately 100m from the waste site, used mostly for cultivation

Figure 2. Mound of Garbage in Agarpara Dumpsite (Mound 1)

Figure 3. Mound of Garbage in Agarpara Dumpsite (Mound 2)

Figure 4. Aerial View of Agarpara Dumpsite

Figure 5. Batches of Garbage being dumped in Titagarh Dumpsite

Figure 6. Leachate from Garbage being accumulated in Titagarh Dumpsite

Figure 7. Agricultural Plots around dumpsite at Titagarh

Figure 8 Aerial View of Titagarh Dumpsite

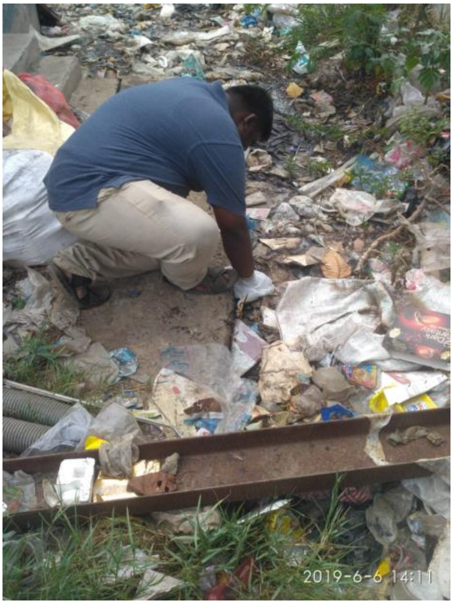

Figure 9. Solid Sample Collection

Figure 10. Liquid Sample collection

3. Analysis Method

We examined the physical chemical as well as biological properties of the samples. Table-2 provides the content of toxic and heavy metals. For this, we performed a rigorous chemical analysis. Sediments were analysed for rear earth and trace elements by employing standard calibration method.

Table 2. Trace elements and Rare earth elements content

Sample Name	SDC-1	SBC-1	SB-1	SB-2	JSD-1
Calibration Method	Sediment T and RE				
As (PPM)	4.8	21.6	11.6	13.5	8.7
Ba (PPM)	690.9	825.2	673.2	752.5	527.7
Cd (PPM)	1.7	0.3	0.3	1.5	0.6
Co (PPM)	16.4	27	12.6	10.5	11.6
Cr (PPM)	51	115.2	128.9	144.9	22.9
Cu (PPM)	29.9	26.7	141.1	403.8	27.2
Ga (PPM)	21.3	27	19.2	14.5	17.3
Hf (PPM)	8.8	4.5	6.6	7.1	1.4
In (PPM)	0.1	0.1	0.1	0.1	0.1
Mo (PPM)	0	0	2.6	2.5	0
Nb (PPM)	19.8	17	18.2	15.9	12.6
Ni (PPM)	32.3	92.5	50.6	48.6	5.5
Pb (PPM)	25.3	35.7	110.3	191.1	15.5
Rb (PPM)	130.4	142	155.8	137.9	79.4
Sc (PPM)	14.2	23.9	16.4	12.1	10.2
Se (PPM)	0.6	1.5	1.2	0.9	0.6
Sr (PPM)	184.6	187.3	186.8	226.8	384.7
Ta (PPM)	1.1	0.9	1.6	1.6	1.3
Th (PPM)	11.8	13.8	15.5	12.4	4.7
U (PPM)	4.2	5.2	4.2	4.2	4.2
V (PPM)	96.6	232.9	99.1	87	78.8
Yb (PPM)	3.3	4.5	7.1	7.2	1.7
Zn (PPM)	106.1	193.4	309	1008.3	109
Y (%)	0.003	0.004	0.003	0.003	0.002
Ce (%)	0.009	0.011	0.008	0.008	0.004

SDC-1= Standard, SBC-1= Standard, SB-1= Soil sample 1, SB-2= Soil sample 2, JSD-1= Standard

Table 3. Major elements in oxide form

Sample Name	JSD1	SB1	SB2	SB1 RPT	SDC1	SBC1
Calibration Method	sediments-11-6-19					
Na2O (%)	2.42	0.94	1.19	0.95	2.1	0.74
MgO (%)	2.02	1.16	1.52	1.18	1.6	2.79
K2O (%)	2.36	2.15	2.31	2.15	3.35	3.84
CaO (%)	3.05	3.18	6.58	3.19	1.49	3.04
Fe2O3 (%)	5.46	5.25	4.93	5.25	6.14	8.42
Al2O3 (%)	15.26	11.82	9.83	11.96	15.18	21.27
SiO2 (%)	62.71	50.33	49.29	50.49	62.67	45.66
P2O5 (%)	0.143	0.4443	0.9802	0.4459	0.1693	0.2746
MnO (%)	0.09	0.07	0.08	0.06	0.09	0.13
TiO2 (%)	0.6933	0.8483	0.7182	0.8498	0.9515	0.792
ZrO2 (PPM)	209.2	336.2	280.8	337.9	407.6	179.6

JSD-1= Standard, JSD-1= Standard, SB-1= Soil sample 1, SB-2= Soil sample 2, SB1-RPT= Soil sample 1 repeated, JSD-1= Standard

Major elements in oxide form has been provide in Table-3. This includes sodium, Magnesium, Potassium, Calcium, Iron, Tungsten, Silicon, Phosphorous, Titanium, Manganese, Zirconium etc. All data is given in parts per million (PPM). In Table-4, we give the pH, total dissolved solid (TDS) and oxidation reduction potential (ORP) of the samples collected. It is a quantitative measure of the rate of oxidation disinfection caused by the addition of effects of all oxidants in water bodies. Oxidation cause the increase in disinfection activities. Therefore, the level of biological pollution is directly related to the ORP. Total dissolved solids in water also include common inorganic salts and are a measurement of the hardness. A higher TDS content in water will be unsuitable for use. To study the physical properties of these samples we choose one of them (Agarpara soil sample 1). Hence, we measure the magnetic inductance, thermal and electrical conductivities of the samples. We designed our experiment to measure the magnetic susceptibility of the samples which is given in this article (Table 5). In order to study the thermal conductivity, we made use of Lees and Charlton's apparatus. The biological standards of the sample were evaluated by isolating and culturing various bacterial strains.

4. Characterization of the solid waste

The sample hence collected from the different mounds in Agarpara dumpsite were studied due to its impact on the huge population nearby. Physio Chemical analysis as well as biological study were also carried out. Magnetic properties were studied because of the magnetic inductive effects on communication in nearby area as well as the heat retentive nature of the sample thus increasing the temperature of the locality. It also emits huge emission. Thermal conductivity was measured by Lees method as discussed later. It is important in the subterranean biochemical process and also the leaching of the waste. Salinity and pH level along with the estimation of total dissolved solids were carried out and it has been found to have significant effect in bacterial growth and production of algae in the runoff that sweep the mounds during runoff. It breeds pollution in algae pond, leachate rich wetlands and other aquatic menace.

Table 4 Physiochemical parameters

Sample Name	Location	pH	ORP	TDS
WS3 Titagarh	Titagarh	8.2	112	262
S WS3 Titagarh	Titagarh	8.1	110	257
SWS2 Titagarh	Titagarh	7.5	128	623
WS4 titagarh	Titagarh	7.4	133	702
S WS4 Titagarh	Titagarh	7.5	135	695
WS1 Agarpara	Agarpara	7.6	-266	CD
S WS1 Agarpara	Agarpara	7.5	-274	CD
Soil 1	Agarpara	8.6	233	922
Soil 2	Titagarh	8.2	247	910

WS= Water sample, S WS3= standby of Water sample3; *CD = Cannot be detected

4.1 Measurement of Inductance in Different Sample

Inductance is the physical property of a conductor or circuit that causes an electromotive force to be generated due to a change in the current flowing in it. Inductance depends on the magnetic permeability of the material. Magnetic Permeability is the measure of the ability of a material to support the generation of a magnetic field within itself. Therefore, it is the degree of magnetization that a material obtains in response to a applied magnetic field. Magnetic Susceptibility: Magnetic susceptibility on the other hand is a dimensionless proportionality constant which indicates the degree of magnetization of a substance in response to an applied magnetic field. Magnetizability is a related term and is the proportion between magnetic moment and magnetic flux density. The technique used here is basic and the principle is from basic electrodynamics. We first measure the magnetic induction with empty sample holder and next fill it up with samples. Using it as the core material we vary the current and measure the magnetic fields. The working formula is given below and the final results are tabulated in Table 5. The working formula for Magnetic Permeability (μ) is given as $\mu = L^2 l/N^2 a$; Magnetic Susceptibility (χ) = μ-1; Where L= Self Inductance; N= Number of turns

Table-5. Magnetic permeability of different materials

Sample	Inductance In mH.	Relative Magnetic Permeability (μ) ×10-7	Magnetic Property
I	10.47	0.92919	Diamagnetic
II	10.45	0.92556	Diamagnetic
III	10.46	0.92733	Diamagnetic
IV	10.46	0.92733	Diamagnetic

4.2 Measurement of Thermal Conductivity

The thermal conductivity of the samples was studied by the method prescribed by Lee and Charlton and the cooling graph was plot. From there the Thermal conductivity was calculated. They are given in Table 6. The cooling curve for the samples has an exponential decay. The cooling graph measures the heat retaining capacity and in turn is instrumental in influencing the surrounding physio-chemical environment. This data is crucial as it maintains temperature in waste mounds which supports the completion of certain chemical reactions. The methane production largely depends on temperature, as a result the green house emission are indirectly dependent on thermal properties.

Lee's Apparatus

The apparatus consists of a metallic disc residing on a 5 cm deep hollow cylinder which is the steam chamber and is of same diameter. It consists of two ports, an inlet and another outlet for steam. Additionally, it has radial holes to insert thermometers. Thermal conductivity is measured when steam is passed through the cylindrical vessel when a steady state is reached. Under steady state conditions, heat conducted through the bad conductor equals the heat radiated from the Lees disc. The cooling curve is a measure when the heating is stopped and the cooling is through the conductor.

Table 6. Thermal Conductivity of different samples from Agarpara site

Sample	Thermal Conductivity (calorie cm/cm^2 ºC sec)
I	6.0875*10(-3)
II	5.427*10(-3)
III	6.008*10(-3)
IV	3.9404*10(-5)

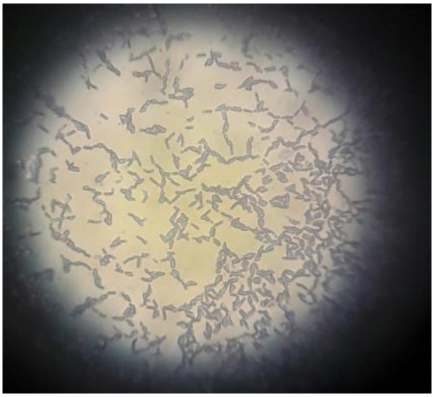

Figure 11. Bacteria in sample II

4.3 Existance of Biological Entities.

Sample collection: Soil sample mixed with waste was collected in sterile zip-lock plastic pouch maintaining aseptic conditions and refrigerated at 4 °C and marked accordingly to their source and point of collection. The collected samples were brought to the laboratory for isolation of soil bacteria. The process of Isolation of bacteria from waste samples consists of the following stages. Firstly, serial dilution techniques were used for the isolation of bacteria. Here sample suspension was prepared by adding soil mixed with waste (1g) and was added to 100 ml of sterile water (the stock) and shaken vigorously for at least 1 minute. Four types of samples were prepared as a stock. The dilute was then sedimented in a short period. 1 ml from the stock was transferred to the 10-1 dilution blank using a fresh sterile pipette. Kept in incubator for 24 hours. Pour plate method was performed for the growth of bacteria. After successful growth of microorganisms, the pure cultures of bacteria were sub-cultured in Nutrient Agar slants; incubated at 37 °C to achieve vigorous growth. The type of bacteria is identified by gram staining. Results of biological test reveal that in total 4 isolates of bacteria were obtained from same environmental sample. Most of them were gram positive rods. An enlarged photograph is shown in figure 11. Biochemical tests were carried out and the result of Oxidase Test, Catalyse Test, Methyl Red Test, Triple Sugar Ion Test, Indole Test, Urease Test, Coagulase Test reveal that both Bacillus and Staphylococcus bacteria were present.

5. Conclusions

The finding of our work will be helpful in proper planning and land usage. It will also be helpful to predict and categories the level of toxicity and act accordingly. The urban local bodies and planning commissions if provided with these data will surely come out with solutions beneficial to the environment and human health. The characterisation of MSW is important in order to recycle them and identify locations using GIS enabled technology to minimise negative impact on environment and population. This may also open up some scope for generating employment in the recycle industry and creating a circular economy.

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