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Characterisation of Municipal Solid Waste for Management and Disposal Purposes

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Abstract

This paper studies the physical, chemical and biological properties of Municipal solid wastes of Agarpara dumpsite in Kolkata. Physical tests like Thermal conductivity, magnetic permeability, Optical activity have been studied. Chemical studies like pH, Salinity, TDS, as well as presence of different functional groups have been studied. Bacterial growth and identification have also been studied. The purpose of the studies is to quantify the potential for recycling and processing and the burden of storing and environmental degradation. The results thus obtained may be helpful in the understanding of the different methods to be used in their disposal and management.

Keywords: Municipal Solid Waste; Physical; Chemical; Biological Characterisation

Introduction

India being the second largest nation in the world, with a population of 1.21 billion, accounts for nearly 18% of world's human population, but it does not have enough resources or adequate systems in place to solve its solid wastes [1]. She is facing a sharp contrast between her increasing urban population and available services and resources. Solid waste management (SWM) is one such service where there is a possibility for India to generate employment, improve the environment and reduce the gap between have and have not as well as the rural - urban divide. The current SWM services are found to inefficient, incurring heavy expenditure and are potential threats to the public health and environmental quality [2]. Improper methods of solid waste management deteriorate public health, causes environmental pollution, accelerates natural resources degradation, causes climate change and greatly impacts the quality of life of citizens.

For waste to be properly managed and its proper disposal we first need to check for its properties, namely physical, chemical and biological. After knowing its properties, we can analyze its effect on the surrounding environment and effectively plan counter measures and if possible, to get some reuse out of it. In this project we analyze the Physical, chemical, biological characteristics of waste from dumping site in Kamarhati Municipality, giving all a general idea of the composition and characteristics of waste dumped in open in the whole KMDA area [3-5]. Saleh TA has done novel work in this field of waste management using nanotechnology and desalination process [6-10]. Similar technology or some variants may be useful in treating MSW.

Municipal solid waste (MSW) commonly known as trash or garbage in India, is a waste type consisting of everyday items that are discarded by the public. Municipal Solid Waste (MSW) management is the process associated with the control of generation, storage, collection, transfer, processing and disposal of solid waste, in a way which is governed by the best principles of public health, economics, engineering, aesthetics and other environmental considerations.

The composition of municipal solid waste varies greatly with space and time. In municipalities and corporations who have a well-developed waste recycling system, it (waste) mainly consists of plastic film and non-recyclable packaging materials. In developed areas without sufficient recycling activity it predominantly includes market wastes, yard wastes, food wastes, plastic containers and product packaging materials, and other miscellaneous solid wastes from commercial, institutional, residential and industrial sources. MSW also has a significant share of industrial wastes, agricultural wastes, medical waste, radioactive waste or sewage

sludge. It is thus important to characterize the waste and choose an exact method for their processing. The motivation of the present paper is to find the physio-chemical properties of the waste substance and its effects on the biological aspects. We have studied physical properties like thermal and electrical conductivities, magnetic properties, as well as optical activity. Further we studied the chemical properties like pH, salinity, TDS as well as the presence and quantification of heavy metals and functional groups. The presence of chiral compounds has also been detected. Finally, the presence of certain strains of bacteria and their growth has been studied.

The paper is organized in the following manner. In section two we brief about the composition and distribution of MSW in Kolkata. In section three we characterize the samples collected based on physical, chemical and biological parameters. Finally, we conclude on some remarks on the effects of such wastes on human health and the waste disposals techniques may be carried out.

Composition and Distribution

According to 2011 Census, Kolkata houses about 4.5 million people while the number of people in Kolkata and its provincial regions was 14.1 million, making it the third-most packed metropolitan locale in India. Today the figure is high. It houses about 8 million populations. Therefore, a large number of resources are used up daily and as a result huge amount of waste is generated. It is claimed that about 3000 tons of waste is generated per day [1-3]. In the following table we give a comparative study MSW Composition (in %) in Kolkata During 1995 & 2010 (Table 1).

Parameters	1995	2010
Biodegradables	44.29	50.56
Green Coconut Shells	8.51	4.5
Paper	4.64	6.07
Plastics	3.22	4.88
Metals	0.43	0.19
Glass & Crockery	1.72	0.34
Coal	3.10	-
Inert	26.82	29.6
Others	7.27	3.86

Table 1: Composition of waste in 1995 and 2010

In order to study the constituents of the MSW in the aforesaid dumpsite we bore holes in the mounds about 6 inches from the surface by using an auger. There were 3 mounds and we collected sample from each of them. The first mound was 4 years old and no fresh material was dumped there since the last four years and green vegetation grew over it. The second mound was 2 years old and majority of it contained ashes produced from burning the waste either by human intervention or naturally due to the action of methane. The third mound contained very recent garbage that was still in the rotting phase. There was a forth heap which contained waste from paper factory. Hence forth we will refer these samples as samples I, II , III and IV.

Characterization of the Solid Waste

The sample thus collected from the different mounds in that location were studied. Physio Chemical analysis as well as biological study were also carried out. Magnetic properties were studied because of the effect on magneto-inductive communication in nearby area as well as the heat retentive nature of the sample. Thermal conductivity was measured and it is important in the subterranean biochemical process as well as leaching of the waste. pH and salinity as well as the TDS studies were carried out which has significant effect in bacterial growth and algae production in the runoff that swept the mounds.

Measurement of Inductance in Different Sample

Inductance is the property of an electric conductor or circuit that causes an electromotive force to be generated by a change in the current flowing. Inductance depends on the magnetic permeability.

Magnetic Permeability: In electromagnetism permeability is the measure of the ability of a material to support the formation of a magnetic field within itself. Hence, it is the degree of magnetization that a material obtains in response to a applied magnetic field.

Magnetic Susceptibility: Magnetic susceptibility is a dimensionless proportionality constant that indicates the degree of magnetization of a material in response to an applied magnetic field. A related term is magnetizability, the proportion between magnetic moment and magnetic flux density. The technique used here is based on the basic principle. 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 2.

Working Formula: Magnetic Permeability (μ) = L^2l/N^2a; Magnetic Susceptibility (χ) = μ-1; Where L= Self Inductance
N= Number of turns

Sample	Inductance In mH.	Relative Magnetic Permeability (μ) $\times 10^{-7}$	Magnetic Susceptibility (χ)	Magnetic Property
I	10.47	0.92919	0.999999	Diamagnetic
II	10.45	0.92556	0.999999	Diamagnetic
III	10.46	0.92733	0.999999	Diamagnetic
IV	10.46	0.92733	0.999999	Diamagnetic

Table 2: Magnetic Permeability of Different Materials

Measurment Electricical Conductivity and Optical Activity in Different Sample

We next measured the electrical conductivity and the optical activity. We have plotted the data and found that there exist a chirality in the material that shows a reverse change in the decrease of rotation angle with increasing electrical conductivity. The electrical conductivity is measured by way of a conductivity meter. We also measured the optical activity or optical rotation by using a polarimeter. Since optical rotation is associated with chirality, we studied the variation of conductivity which is a measure of ionization with dilution. The variation mean rotation with conductivity for the four samples is shown in Table 3.

Sample	No of Obs	Conductivity (standard unit)	Mean Rotation (Degree)
I	1	245	1.165
	2	134.5	0.64
	3	73.1	0.27
	4	47.8	0.62
II	1	399	0.345
	2	213	0.24
	3	115.9	0.27
	4	64.2	0.3
III	1	170	0.33
	2	101.2	0.4
	3	62.8	0.22
	4	35.3	0.6
IV	1	188	0.3
	2	104.22	0.22
	3	64.6	0.45
	4	49	0.22

Table 3: Conductivity vs. Optical Activity Data

Measurement of Thermal Conductivity

The thermal conductivity of the samples were studied by Lee and Charlton's method and the cooling graph was plot. From there the Thermal conductivity was calculated. They are given in Table 4. The cooling curve for sample II in Figure 1. Other samples follow

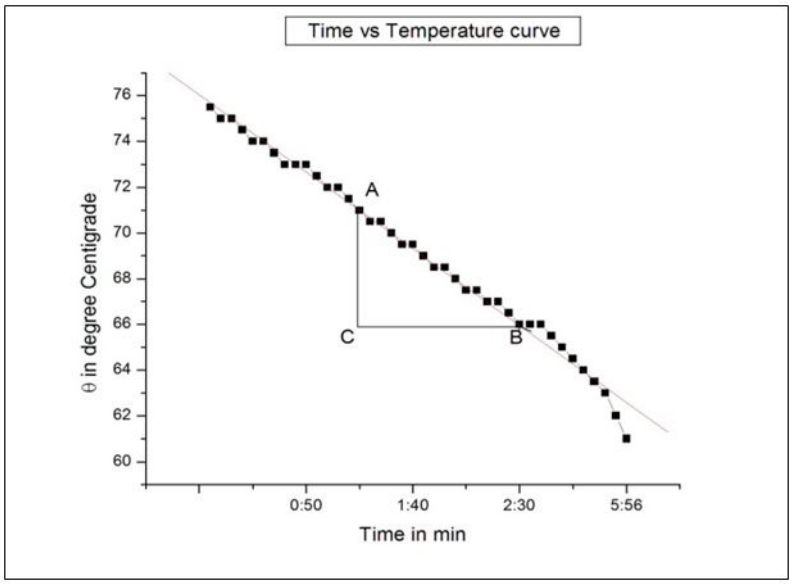

Figure 1: Cooling Curve for Sample I, Upper Disk 4mm Thickness, Lower Disc 10 mm Thickness. Sample Thickness 2 mm

Sample	Thermal Conductivity (calorie cm/cm² °C sec)
I	6.0875*10(-3)
II	5.427*10(-3)
III	6.008*10(-3)
IV	3.9404*10(-5)

Table 4: Thermal Conductivity of different Samples

similar pattern with varying gradients. The cooling graph is a measure of the heat retaining capacity and in turn instrumental in influencing the surrounding environment. This data is important as it maintains temperature in waste mounds which supports certain chemical reactions. The methane production largely depends on temperature, as a result the green house emissions are indirectly dependent on thermal properties.

Existance of Functional Groups and Heavy Metals

Tests were carried out and it was found that several functional groups were present in the samples. While Nitro groups, Amide groups and aldehydes were present, there was no alcohol group or acids. The tests were standard chemical techniques used to identify functional groups and therefore require no further discussions. Level of lead was high in the samples.

Existance of Biological Entities

Sample collection: Sample (soil mixed with waste) was collected in sterile zip-lock plastic maintaining aseptic conditions, stored at 4 °C and marked accordingly to their source and location. The collected samples were brought to the laboratory for isolation of soil bacteria.

Isolation of bacteria from waste samples: Serial dilution techniques were used for the isolation of bacteria. In this technique sample suspension was prepared by adding soil mixed with waste (1g) was added to 100 ml of sterile water (the stock) and shaken vigorously for at least 1 minute. 4 types of samples were prepared as a stock. The dilute was then sedimented for a short period. One 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 NA slants; incubated at 37 °C to achieve vigorous growth. 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 2.

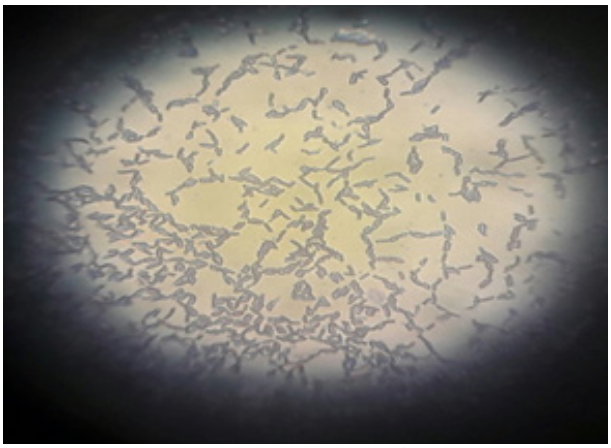

Figure 2: Bacteria in sample II

Biochemical tests were carried out and the result is given in the following Table (Table 5). The detailed processes are not included as it is very well known

	Sample			
Test	I	II	III	IV
Oxidase Test	+	+	+	+
Catalase Test	+	+	+	+
Methyl red Test	-	+	-	+
Triple sugar ion Test	+	+	-	+
Indole Test	+	+	+	+
Urease Test	-	-	-	-
Coagulase Test	-	-	+	+
Identification	-	*Bacillus sp.*	-	*Staphylococcus sp.*

Table 5: Biochemical Test

Conclusion

The wastes thus characterized give us an idea of the composition and nature of waste. These results may be helpful in the and reuse of the material. Government policies can therefore be made to address these issues effectively. Studies on waste in other countries are also analyzed and the picture is similar worldwide to a great extent for developing countries [11-15]. In future the study on intricate structure and properties is planned to be carried out. Thus, wastes which show higher levels of thermal conductivity must not be exposed in the sun as this might increase the surrounding layers; rather it needs to be covered by sand and soil. Also, heavy metals maybe removed from the soil by employing techniques like employing Silica CNT composites or something similar. Multi wall CNT can be also useful here [9]. Such studies were carried out by researchers [10]. Surface properties help contain heavy metals; therefore, we can also suggest use of similar technologies for removal of pollutants [7]. The acidic or alkaline nature of waste materials may be made a potential factor for their degradation process [10]. This would also help in controlling growth of harmful bacteria. The study is helpful for finding a solution towards integrated waste management and holds a promise towards effective techniques [16-18].

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