IMPACT OF SOLID WASTE EFFECT ON GROUND WATER AND SOIL QUALITY NEARER TO PALLAVARAM SOLID WASTE LANDFILL SITE IN CHENNAI

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ABSTRACT

Soil and groundwater samples were collected nearer to Pallavaram Solid waste landfill-site in Chennai to study the possible impact of solid waste effect on soil and ground water quality. The physical and chemical parameters such as temperature, pH, hardness, electrical conductivity, total dissolved solids, total suspended solids, alkalinity, calcium, magnesium, chloride, nitrate, sulphate, phosphate and the metals like sodium, potassium, copper, manganese, lead, cadmium, chromium, nickel, palladium, antimony were studied using various analytical techniques. It has been found that most of the parameters of water are not in the acceptable limit in accordance with the IS 10500 Drinking Water Quality Standards. It is concluded that the contamination is due to the solid waste materials that are dumped in the area.

***Key words**: Pallavaram, water quality, ground water, solid waste.*

INTRODUCTION

Enormous amounts of solid waste produced in and around Chennai urban areas are dumped nearer to Pallavaram solid waste landfill site. This municipal solid waste normally termed as “garbage” is an inevitable by product of human activity which is disposed through dumping. Solid waste land filling is the most common method of solid waste disposal. The landfill site nearer to Pallavaram are open dumpsites, because the open dumpsites are low operating costs and lack of expertise and equipment provided no systems for leachate collections. Open dumps are unsightly, unsanitary, and generally smelly. They attract scavenging animals, rats, insects, pigs and other pests. Surface water percolating through the trash can dissolve out or leach harmful chemicals that are then carried away from the dumpsites in surface or subsurface runoff. Among these chemicals heavy metals are particularly insidious and lead to the phenomenon of bioaccumulation and biomagnifications. These heavy metals may constitute an environmental problem, if the leachate migrates into the ground water. The presence of bore well at the landfill sites to draw ground water threatens to contaminate the ground water[1].

A water pollutant is a chemical or physical substance present in it at the excessive levels capable of causing harm to living organisms. The physical hazards are the dissolved solids and suspended solids. The chemical hazards are the copper, manganese, lead, cadmium, phosphate, nitrate *etc*. As the public health concern, the ground water should be free from physical and chemical hazards. The people in and around the dumping site are depending upon the ground water for drinking and other domestic purposes. The soil pollution arises due to the leaching of wastes from landfills and the most common pollutant involved is the metals like copper, lead, cadmium, mercury etc., The Contamination of ground water and soil is the major environmental risk related to unsanitary land filling of solid waste. The study of Impact of solid waste on water quality of Bishnumati and surrounding areas in Kathmandu, Nepal reveals that the river is heavily polluted[2].

Impacts of solid waste on health: The group at risk from the unscientific disposal of solid waste include – the population in areas where there is no proper waste disposal method, especially the pre-school children; waste workers; and workers in facilities producing toxic and infectious material. Other high-risk group includes population living close to a waste dump and those, whose water supply has become contaminated either due to waste dumping or leakage from landfill sites. Uncollected solid waste also increases risk of injury, and infection. In particular, organic domestic waste poses a serious threat, since they ferment, creating conditions favourable to the survival and growth of microbial pathogens. Direct handling of solid waste can result in various types of infectious and chronic diseases with the waste workers and the rag pickers being the most vulnerable. Exposure to hazardous waste can affect human health, children being more vulnerable to these pollutants. In fact, direct exposure can lead to diseases through chemical exposure as the release of chemical waste into the environment leads to chemical poisoning. Many studies have been carried out in various parts of the world to establish a connection between health and hazardous waste. Waste from agriculture and industries can also cause serious health risks. Other than this, co-disposal of industrial hazardous waste with municipal waste can expose people to chemical and radioactive hazards. Uncollected solid waste can also obstruct storm water runoff, resulting in the forming of stagnant water bodies that become the breeding ground of disease. Waste dumped near a water source also causes contamination of the water body or the ground water source. Direct dumping of untreated waste in rivers, seas, and lakes results in the accumulation of toxic substances in the food chain through the plants and animals that feed on it.

Disposal of hospital and other medical waste requires special attention since this can create major health hazards. This waste generated from the hospitals, health care centres, medical laboratories, and research centres such as discarded syringe needles, bandages, swabs, plasters, and other types of infectious waste are often disposed with the regular non-infectious waste. Waste treatment and disposal sites can also create health hazards for the neighbourhood. Improperly operated incineration plants cause air pollution and improperly managed and designed landfills attract all types of insects and rodents that spread disease. Ideally these sites should be located at a safe distance from all human settlement. Landfill sites should be well lined and walled to ensure that there is no leakage into the nearby ground water sources.

Recycling too carries health risks if proper precautions are not taken. Workers working with waste containing chemical and metals may experience toxic exposure. Disposal of health-care wastes require special attention since it can create major health hazards, such as Hepatitis B and C, through wounds caused by discarded syringes. Rag pickers and others who are involved in scavenging in the waste dumps for items that can be recycled may sustain injuries and come into direct contact with these infectious items.

Diseases: Certain chemicals if released untreated, *e.g.* cyanides, mercury, and polychlorinated biphenyls are highly toxic and exposure can lead to disease or death. Some studies have detected excesses of cancer in residents exposed to hazardous waste. Many studies have been carried out in various parts of the world to establish a connection between health and hazardous waste.

This study involves the water and soil quality analysis in the Pallavaram solid waste dumpsite nearer area. The aim of the study is to understand how the soil and water gets polluted due to the dumping of solid waste.

EXPERIMENTAL

Study area: Pallavaram is located at 12.98° N 80.18° E. It has an average elevation of 16 metres (52 feet). The Pallavaram land filling dumpsite is in the beginning of Grand South Trunk road connecting Old Mahabalipuram road by 200 feet road. Pallavaram Land filling dumpsite is surrounded by residential areas in which they are heavily affected by both soil and water pollution through the leach out of hazards from the solid waste. Figure 1 shows the study area. The soil and water collected from the Joy Nagar (Fig 2 and Fig.3) which is nearer to the solid waste dumpsite. W1, W2 and W3 are the water samples collected in Joy Nagar nearer to Pallavaram landfill dumping site. S1, S2, S3 and S4 are the soil samples collected in Joy Nagar nearer to Pallavaram landfill dumping site. SW1, SW2, SW3 and SW4 are the solid waste samples collected in the Pallavaram landfill dumping site.

Sampling and Methodology **:** The Preliminary survey on the quality of ground water, soil and solid waste samples was conducted in the month of January 2008, because the ground water and soil get polluted due to solid waste dumping nearer to the location. The water samples and soil samples were collected along with three grab samples during first week of the month between 7.00 A.M. to 10.00 A.M.

***Water*:** Sample Collection, preservation and analysis were done as per the standard methods[2]. Water samples were taken at each station. Three water samples were collected at different locations at Joy Nagar. The polyethylene sample containers cleaned by 1 mol/L of nitric acid and left it for 2 days followed by thorough rinsing of distilled water. Two litres of samples were collected for the analysis. The generally suitable techniques for the preservation of samples followed as per Indian standard methods. The pH, Electrical conductivity, Total alkanity, hardness and chloride test were done at the site. Total suspended solids. nitrate, phosphate and sulphate were analysed as soon as possible. The samples for trace metal analysis were acidified with concentration HNO_3 to bring pH < 2.

***Soil samples*:** Sample collection, preservation and analysis were done as per the standard methods[3]. The representative soil samples were collected as per standard methods. The sampling of soil was done using hand augur. The augur was used to bore a hold to the desired depth and then withdrawn. The samples were collected directly from the augur. The sampling area first to be cleaned and first six inches of surface soil was removed with the radius of 6 inches around the drilling location. Begin auguring, periodically removed and deposited accumulated soil onto the plastic sheet. After reaching the desired depth slowly and carefully removed the augur from the hole and the samples were directly from the augur. The composite samples collected and they were kept in the suitable labeled container. The collected soil samples were protected from sunlight to minimise any potential reaction. The dry soil samples for various tests were prepared as per the indian standard method[4]**.** The received soil samples dried in sun or air and the pulverization was done. The pulverised soil was passed through the specified sieve and taken for various analysis.

***Solid waste samples*:** 500 g of representative solid waste samples were collected in the different places of Pallavaram Landfill site on 5th January 2008. The solid waste samples were collected as per the standard procedure[5].

***Laboratory analysis*:** The station-wise distributions of analytical parameters such as physical parameters and metals are shown in Tables 1, 2 and 3 and the analysis was done as per the standard methods[6, 7].

RESULTS AND DISCUSSION

Chemical Characteristics: pH of water samples varies from 5.24 to 6.59. The acceptable limit for the drinking water standard is 6.5 – 8.5. Since W2 does not lie in the limit, it is not suitable for drinking. The pH of soil varies from 6.3 to 7.0 and the solid waste sample varies from 6.4 to 7.3. Total alkalinity values vary from 40 mg/L to 260 mg/L. The desirable limit for total alkalinity is 200 mg/L and the permissible limit in the absence of alternate source is 600 mg/L. The total alkalinity value of water sample S2 is very lower as compared to the standard. Hardness of water sample varies from the 450 mg/L to 669 mg/L. The desirable limit for hardness is 300 mg/L and the permissible limit in the absence of alternate source is 600 mg/L. The calcium concentration varies from 107 mg/L to 169 mg/L and the magnesium concentration varies from 22.5 to 60.1 mg/L. The desirable limit for calcium is 75 mg/L and the permissible limit in the absence of alternate source is 200 mg/L. The desirable limit for magnesium is 30 mg/L and the permissible limit in the absence of alternate source is 100 mg/L. Chlorides are not usually harmful to people; however, the sodium part of table salt has been linked to heart and kidney disease. Sodium chloride may impart a salty taste at 250 mg/L; however, calcium or magnesium chlorides are not usually detected by taste until levels of 1000 mg/L are reached. The desirable limit for chloride is 250 mg/L and the permissible limit in the absence of alternate source is 1000 mg/L. All the water samples fall within the limit.

TDS is generally considered not as a primary pollutant, but it is rather used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of presence of a broad array of chemical contaminants. The values for the present water samples vary from 1622 mg/L to 1809 mg/L. The desirable limit for TDS is 500 mg/L and the permissible limit in the absence of alternate source is 2000 mg/L. The TDS levels of the water come within the limit. Total Suspended Solids (TSS) (measure of the mass of fine inorganic particles suspended in the water values) are in between 24 and 42 mg/L.

Nitrate is one of the most common groundwater contaminant. The excess levels can cause methemoglobinemia, or "blue baby" disease. Although nitrate levels that affect infants do not pose a direct threat to older children and adults, they do indicate the possible presence of other more serious residential or agricultural contaminants, such as bacteria or pesticides. Nitrate in groundwater originates primarily from fertilizers, septic systems, and manure storage or spreading operations. The permissible limit for the nitrate is 45 mg/L. The water samples are in the range of 22.35 to 26.37 mg/L. All the samples are within the permissible range.

Sulfate can be found in almost all natural water. The origin of most sulfate compounds is the oxidation of sulfite ores, the presence of shales, or the industrial wastes. Sulfate is one of the major dissolved components of rain. High concentrations of sulfate in the water we drink can have a laxative effect when combined with calcium and magnesium, the two most common constituents of hardness. The sample contains the sulphate concentration in the range of 351 to 487 mg/L. The desirable limit for sulphate is 200 mg/L and the permissible limit in the absence of alternate source is 400 mg/L. The samples W2 and W3 are not suitable for drinking. Phosphorus is usually present in natural water as phosphates (orthophosphates, polyphosphates, and organically bound phosphates). Sources of phosphorus include human and animal wastes (i.e., sewage), industrial wastes, soil erosion, and fertilizers. Excess phosphorus causes extensive algal growth called "blooms," which are a classic symptom of cultural eutrophication and lead to decreased oxygen levels in creek water. The water samples contain 0.11 to 0.16 mg/L of phosphate.

Sodium is an essential nutrient. The Food and Nutrition Board of the National Research Council recommends that most healthy adults need to consume at least 500 mg/day, and that sodium intake be limited to no more than 2400 mg/day. This low level of concern is compounded by the legitimate criticisms of EPA's 20 mg/L [Drinking Water Equivalency Level (DWEL) or guidance level] for sodium. The maximum permissible level of sodium is 200 mg/L as per WHO guidelines. The present water is having higher concentration as compared to DWEL Level. The sodium level of water is ranging from 449.8 mg/L to 482.2 mg/L.

Metals

***Copper*:** The desirable limit for copper is 0.05 mg/L and the permissible limit in the absence of alternate source is 1.5 mg/L. The undesirable effect beyond the desirable limit is astringent taste, discoloration and corrosion of pipes, fittings and utensils will be caused. The present water samples are having copper ranging from 0.221 mg/L to 0.478 mg/L. Hence, all water samples are contaminated due to copper and not suitable for drinking.

***Manganese*:** The desirable limit for manganese is 0.1 mg/L and the permissible limit in the absence of alternate source is 0.3 mg/L. Beyond this limit taste and appearance are affected and has the adverse effect on domestic uses and water supply structures. The present water samples are ranging from the 0.142 to 2.360 mg/L.

***Cadmium*:** The permissible limit for cadmium is 0.01 mg/L. Beyond this the water becomes toxic. The samples are in the range 0.010 to 0.014 mg/L, slightly more to the permissible limit.

***Nickel*:** The desirable limit for nickel is 0.07 mg/L as per the WHO guidelines for drinking water quality, 2006. The samples are in between 0.029 to 0.154 mg/L. S2 is beyond the limit.

***Lead*:** The permissible limit for lead is 0.05 mg/L. The water sample has no appreciable concentration of lead and it is found to be below the detection level. The detection level is 0.01 mg/L.

***Chromium*:** The permissible limit for chromium is 0.05 mg/L. The water sample has no appreciable concentration of chromium and it is found to be below detection level. The detection level is 0.03 mg/L.

Mercury: The permissible limit for mercury is 0.001 mg/L. The water sample W1 has the concentration of 0.00087 mg/L and the other two water samples have no mercury content.
Modernization and progress has had its share of disadvantages and one of the main aspects of concern is the pollution it is causing to the earth – be it land, air, and water. With increase in the global population and the rising demand for food and other essentials, there has been a rise in the amount of waste being generated daily by each household. This waste is ultimately thrown into municipal waste collection centers from where it is collected by the area municipalities to be further thrown into the landfills and dumps. However, either due to resource crunch or inefficient infrastructure, not all of this waste gets collected and transported to the final dumpsites. If at this stage the management and disposal is improperly done, it can cause serious impacts on health and problems to the surrounding environment.
Waste that is not properly managed, especially excreta and other liquid and solid waste from households and the community, are a serious health hazard and lead to the spread of infectious diseases. Unattended waste lying around attracts flies, rats, and other creatures that in turn spread disease. Normally it is the wet waste that decomposes and releases a bad odour. This leads to unhygienic conditions and thereby to a rise in the health problems. The plague outbreaks in Surat is a good example of a city suffering due to the callous attitude of the local body in maintaining cleanliness in the city. Plastic waste is another cause for ill health. Thus, excessive solid waste that is generated should be controlled by taking certain preventive measures.

Preventive measures: Proper methods of waste disposal have to be undertaken to ensure that it does not affect the environment around the area or cause health hazards to the people living there. At the household-level proper segregation of waste has to be done and it should be ensured that all organic matter is kept aside for composting, which is undoubtedly the best method for the correct disposal of this segment of the waste. In fact, the organic part of the waste that is generated decomposes more easily, attracts insects and causes disease. Organic waste can be composted and then used as a fertilizer.

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Table-1: Water Quality Parameters in Joy Nagar, near the Pallavaram Solid waste dumpsite area

Parameters	Ground water W1	Ground water W2	Ground Water W3	Requirement (Desirable Limit)	Permissible limit in the absence of alternative source	Undesirable effect outside the Desirable Limit
Colour, Hazen units, Max	2	1	3	5	25	Above 5, consumer acceptance decreases
Odour	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	--	--
Taste	Agreeable	Agreeable	Agreeable	Agreeable	--	--
Turbidity, NTU,Max	1.4	0.8	1.1	5	10	Above 5, consumer acceptance decreases
pH value	6.59	5.24	6.56	6.5 to 8.5	No relaxation	--
Electrical Conductivity	2950	3290	3180	--	--	--

@ 25°C , µmhos/cm						
Total alkanity as CaCO3,mg/L	260	40	236	200	600	Beyond this limit taste becomes unpleasant
Total Hardness (as CaCO3) mg/L, Max	515	450	669	300	600	Encrustation in water supply structure and adverse effects on domestic use
Calcium mg/L , Max	144	107	169	75	200	Encrustation in water supply structure and adverse effects on domestic use
Magnesium, mg/L,Max	37.6	22.5	60.1	30	100	Encrustation in water supply structure and adverse effects on domestic use
Chloride , mg/L,Max	729	877	795	250	1000	Beyond this Limit,test,corrosion and palatability are affected
Nitrate , mg/L,Max	22.35	26.37	23.41	45	No relaxation	Beyond this methaemoglobinemia takes place
Sulphate , mg/L,Max	351	487	441	200	400	Beyond this causes gastro intenstinal irritation when magnesium or sodium present
Total Dissolved solids, mg/L	1622	1809	1749	500	2000	Beyond this palatability decreases and may cause gastro intestinal irritation
Total Suspended solids, mg/L	24	38	42	--	--	--
Sodium , mg/L	449.8	482.2	451.5	--	--	--
Potassium , mg/L	22.4	8.0	21.1	--	--	--
Copper , mg/L	0.478	0.388	0.221	0.05	1.5	Astringent taste, discoloration and corrosion of pipes, fitting and utensils will be caused beyond this
Manganese , mg/L	2.360	1.410	0.142	0.1	0.3	Beyond this limit taste/appearance are affected, has adverse effect on domestic uses and water supply structures

Lead , mg/L	BDL	BDL	BDL	0.05	No relaxation	Beyond this limit the water becomes toxic
Cadmium , mg/L	0.010	0.014	0.012	0.01	No relaxation	Beyond this limit the water becomes toxic
Chromium (as Cr6+), mg/l	BDL	BDL	BDL	0.05	No relaxation	May be carcinogenic above this limit
Nickel , mg/L	0.041	0.154	0.029	--	--	--
Phosphate , mg/L	0.16	0.11	0.11	--	--	--
Mercury , µg/L	0.87	BDL	BDL	1	No relaxation	Beyond this limit the water becomes toxic

BDL= Below detection level

Table-2: Soil Quality Parameters in Joy Nagar near the Pallavaram Solid waste dumpsite area

Parameters	Soil S1	Soil S2	Soil S3	Soil S4
pH @ 25°C	6.40	6.30	6.80	7.00
Electrical Conductivity @ 25°C , µmhos/cm	180.2	523	622	290
Lead, mg/kg	19.3	9.53	7.43	51.52
Cadmium, mg/kg	0.40	0.17	0.27	0.27
Copper, mg/kg	36.55	29.53	43.08	25.28
Manganese, mg/kg	65.89	32.74	57.93	110.8
Chromium, mg/kg	44.28	8.41	7.58	6.50
Nickel, mg/kg	9.52	5.41	6.25	4.68
Mercury, mg/kg	0.20	0.055	0.11	0.029
Moisture, %	8.76	9.34	8.42	9.64

Table-3: Solid Waste Quality Parameters in Joy Nagar near the Pallavaram Solid waste dumpsite area

Parameters	Solid waste SW1	Solid waste SW2	Solid waste SW3	Solid waste SW4
pH @ 25°C	6.40	6.70	7.00	7.25
Electrical Conductivity @ 25°C , µmhos/cm	438	485	315	245

Lead, mg/kg	75.08	87.81	62.5	26.74
Cadmium, mg/kg	2.10	1.80	1.52	1.09
Copper, mg/kg	267.9	137.9	66.5	62.5
Manganese, mg/kg	160.2	208.3	172.2	291.6
Chromium, mg/kg	33.8	38.5	28.0	16.3
Nickel, mg/kg	16.0	19.3	16.4	9.51
Mercury, mg/kg	0.37	0.16	0.37	0.098
Moisture, %	2.62	6.84	1.58	2.41

Fig-1:Pallavaram Land fill site area and Joy Nagar in Pallavaram Municipality

Fig-2 : Pallavarm land fill site

Fig-3 : Joy Nagar nearer to Pallvaram Land fill site

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For many of us, water simply flows from a faucet, and we think little about it beyond this point of contact. We have lost a sense of respect for the wild river, for the complex workings of a wetland, for the intricate web of life that water supports.

—**Sandra Postel**, *Last Oasis: Facing Water Scarcity,* 2003