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Potential impacts of leachate generation from urban dumps on the water quality of Pallikaranai Marsh- the only surviving freshwater wetland of Chennai city in India

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Abstract

Wetlands near urban centres are under great environmental pressure due to residential, industrial and commercial developments. In south of Chennai, we have the Perungudi dumpsite in the Pallikaranai Marsh which is a low lying area and closes to the sea level. It is poorly drained and consists of an extensive area of marshy land permanently wet and seasonally inundated. This dumpsite does not have proper lining to prevent leachate migration into underlying and surrounding groundwater environment. There is no importance given for measurement of potential impacts of leachate generation from dumpsite on groundwater quality. Hence, the present works is taken to study the impact on groundwater quality around the Perungudi dumpsite. The study determines the major physico-chemical quality of groundwater and besides it compares COD for the pre-monsoon and post monsoon periods in the water samples in six observation wells in the same location both in dug wells and tube wells. The pH indicates alkaline nature in all the water samples and the EC content in post monsoon period reduces due to the rains which dilutes the water. In the present study, the total dissolved solids in all the water samples were high and exceeded the desired limit of the CPHEEO, 1999. In the case of Hardness, the values are higher during the pre-monsoon period and exceed the maximum permissible limit. COD in the water samples are higher in pre monsoon and lower in the post monsoon period. Pallikaranai is the only surviving wetland ecosystem of the Chennai city which is a curious watch for environmentalists and stakeholders. This study emphasizes the need to protect the dwindling common property resource.

Keywords: Wetland Dumpsite; Ground Water; Water Quality; pH; Total dissolved solids; Electrical conductivity; TDS; Total hardness; COD.

Introduction

Wetlands with a share of 0.0001%, among the global water sources, include swamps, marshes, bogs and similar areas and are an important and vital component of the ecosystem (IUCN, 1996). A wide variety of wetlands exist across the continents because of regional and local differences in hydrology, vegetation, water chemistry, type and quality of soils, topography, climate and other factors. At the earth's surface, fresh water forms the habitat of large number of species. These aquatic organisms and the ecosystem they live in represent a substantial sector of the earth's biological diversity.

Wetlands play an important role in improving the water quality by filtering sediments and nutrients from surface water. Aquatic vegetation helps in removing 90% of the dissolved nutrients like nitrogen and phosphorus and also in adsorption of heavy metals (Nixon and Lee, 1986).

Wetlands near urban centres are under increasing developmental pressure for residential, industrial and commercial facilities. Increasing population and economic growth create high demand for real estate in sub-urban localities. Urban wetlands in certain instances function as recharge areas. This is especially true in communities where ground water withdrawals are heavy. Thus, urban wetlands are essential for preserving public water supplies.

The metropolitan cities of India are under the pressure of demand of water. Chennai is among the worst affected because of its ever-expanding urban population demands for more freshwater. The availability and quality of water always have played an important role in determining quality of life. Water quality is closely linked to water use and to the state of economic development. Freshwater habitats occupy a relatively small portion of the earth's surface when compared to marine and terrestrial habitats. Most of the pollutants mixed with water have led to a steady decline in aquatic life. Physical and chemical characteristics of water bodies affect the abundance, species composition, stability, productivity and physiological condition of aquatic organisms. The physico-chemical parameters of an aquatic body not only reflect the type and diversity of aquatic biota but also the water quality (Hooper *et al*., 2005).

Population growth and rising income have resulted in a rapid growth in Municipal Solid Waste (MSW) generation rate of the city. In Chennai, waste generation per day has been doubled during the last decade. MSW generated in Chennai includes 68 % of residential waste, 16 % commercial waste, 14 % institutional waste and 2 % industrial waste (Essaku *et al*., 2007).

Wetland of Pallikaranai comes under the category of freshwater urban swamp in India. It is adjacent to the Bay of Bengal, about 20 kilometres south of the Chennai city centre, and has a geographical area of 80 square kilometres. Pallikaranai marshland is the only surviving wetland ecosystem of the city and among the few natural wetlands of South India (Wikipedia, the free encyclopedia). It is identified as one of the 94 wetlands under National Wetland Conservation and Management Programme (NWCMP) by the Government of India in 1985-86. In the Pallikaranai marsh, we have the Perungudi dumpsite which is operational since 1986. The Perungudi dumping ground (PDG) is low lying area and closes to the sea. It is poorly drained and consists of an extensive area of marshy land permanently wet and seasonally inundated. The current dumping rate is about 2,000 t/day. The total area of this site is about 800 acres of which about 400 acres have been used so far for dumping. PDG lies at 12°57’13.5” North and 80°14’5.8” East. (Karthikeyan et al, 2011). This dumpsite does not have proper lining to prevent leachate migration into underlying and surrounding groundwater environment. There is no importance given for measurement of potential impacts of leachate generation from dumpsite on groundwater quality. Hence, the present works is taken to study the nature of groundwater around the Perungudi dumpsite for assessing its impact on groundwater quality.

Different type of vehicles are deliver the waste to the site resulting in a wide range of unloading procedures like end tipping, side tipping and manual unloading. Unloaded waste is tipped in conical piles and then spread out by bulldozers. No cover of any description is placed over the spread waste to inhibit the ingress of surface water or to minimize litter blow and odours or to reduce the presence of vermin and insects. Since, there are no specific arrangements to prevent flow of water into and out of landfill site, the diffusion of contaminants released during degradation of land filled wastes, may proceed uninhibited. The refuse is dumped in low-lying areas haphazardly and as a result, the adjoining land gets enriched in salts and trace metals. Dumped waste comes in contact with water causing pollution depending upon environmental conditions and solubility of metals. Our study focuses on the environmental problems which are due to urban dumps in the Pallikaranai Marsh.

Objectives

To determine the quality of ground water around Municipal solid waste disposal site in Pallikaranai and its adjacent area. A network of 13 dug wells, 9 tube wells and 4 surface water samples was established as observation wells. The comparison of COD was done for the pre-monsoon and post

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monsoon periods for June 2008. In January 2009, June 2009 and January 2010, the water samples in six observation wells in the same location both in dug wells and tube wells for pre and post monsoon periods.

The Perungudi dumpsite is not fully secured by boundary wall on all sides leading to spreading of the dumped waste to nearby localities. Generally the impacts of a dumpsite may be summarized as follows:

- Groundwater contamination by the leachate generated by the waste dump
- Surface water contamination by the runoff from the waste dump
- Bad odour, pests, rodents and wind-blown litter in and around the waste dump
- Generation of inflammable gases (eg. Methane) within the waste dump
- Bird menace above the waste dump which affects flight of aircraft
- Fires within the waste dump
- Erosion and stability problems relating to slopes of the waste dump
- Epidemics through stray animals
- Acidity to surrounding soil

Vencatesan (2007), reviewed issues related to shrinkage of Pallikaranai wetland. It was stated that the degradation of the Marsh was due to dumping of garbage and the disposal of partially treated sewage.

Study Area

The Pallikaranai dumpsite is located south of Velachery, lies between the old Mahabalipuram road in the east, Velachery-Tambaram road on the west, Sittalappakkam on the south and Alandur on the north. It is a large topographic depression termed as the Pallikaranai Depression, stretching approximately 10 km from north to south and is about to 3 km wide from west to east (Fig.1). The area is low lying marshy land and is connected to the sea via the Buckingham canal and the Kovalam Estuary at the southern end of the depression. The dumpsite lies between 2 to3 km west of the Buckingham Canal and is at 3.5 to 4.5 km west of the Bay of Bengal coastline. The locations of the dug wells, tube wells and surface water are the sample well locations of the Central Ground Water Board, Chennai. With the prior permission of Central Ground Water Board, Chennai, the following locations were chosen for this study which is within 2.5km from the Perungudi dump yard. . The locations were identified using the Global Positioning System (GPS), the latitude and longitude values were recorded.

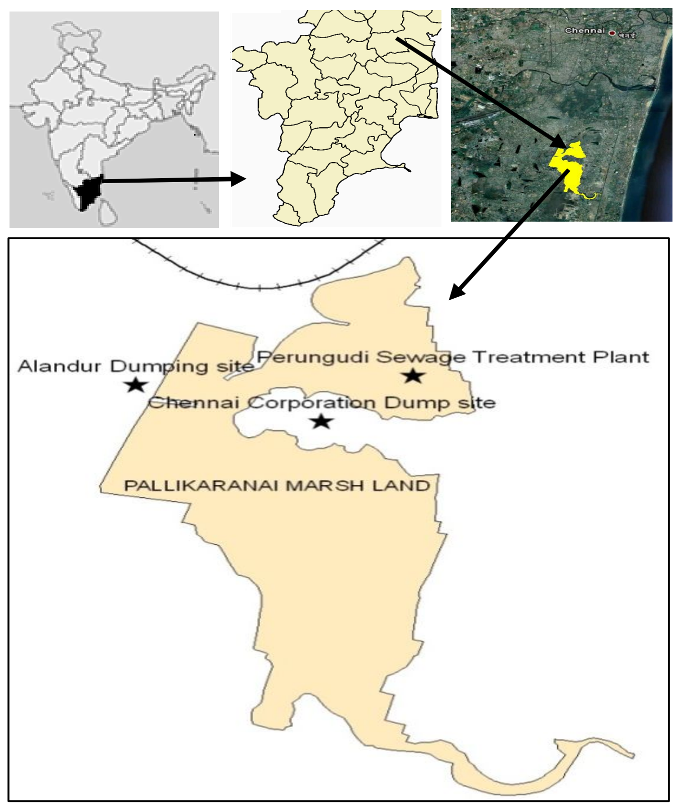

Fig.1 Location of pallikaranai marsh land

Methodology

Groundwater samples were collected in two seasons of pre monsoon and post monsoon for a period of two years (June 2008 to January 2010) from13 dug wells, 9 tube wells, and surface water samples from Pallikaranai Marsh and Okkiyam Madugu were collected surrounding the dumping yard. Location of the wells are given in Table.1

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Table 1. Locations of the wells in the study area

Location	Latitude	Longitude	Well type
PallikaranaiPanchayat	12.9314	80.1978	dugwell
Pallikaranai-New colony	12.9336	80.2069	dugwell
Pallikaranai-Indira nagar	12.9317	80.2092	dugwell
Perungudi-Elumalai-house	12.9556	80.2403	dugwell
Perungudi-Thirumalainagar	12.9514	80.2272	Dugwell
Thuraipakkam	12.9514	80.2283	Dugwell
Thuraipakkam-shanmugam-house	12.9497	80.2267	Dugwell
Thuraipakkam-Adiparasakthik.m	12.9619	80.2286	Dugwell
Thuraipakkam-Jayabalan-house	12.9500	80.2267	Dugwell
Thuraipakkam-Balamurugan garden	12.9397	80.2242	Dugwell
Thuraipakkam-PTC quarters	12.9586	80.2439	Dugwell
Mettukuppam-Pillaiyarkoil street	12.9372	80.2217	Dugwell
Opp-balaji dental college	12.9411	80.2006	Dugwell
Pallikaranai-lake	12.9297	80.2050	surface water
Perungudi-lake(100ft road)	12.9511	80.2278	surface water
Thuraipakkam-near-LF	12.9500	80.2267	surface water
Okkiyammadhagu	12.9228	80.2325	surface water
Perungudi-Ramappanagar	12.9592	80.2272	tube well
Perungudi-Premvillaapts	12.9522	80.2263	tube well
Perungudi-Thirumalainagar	12.9514	80.2272	tube well
Perungudi-Elumalai-house	12.9556	80.2403	tube well
Thuraipakkam-shanmugam-house	12.9497	80.2267	tube well
Thuraipakkam-Adiparasakthik.m	12.9619	80.2286	tube well
Thuraipakkam-Deenan house	12.9500	80.2267	tube well
Thuraipakkam-Jayabalan-house	12.9500	80.2267	tube well
Mettukuppam-Pillaiyarkoil street	12.9372	80.2217	tube well

Separate samples were collected for BOD analysis. The samples were immediately transported to the laboratory and carefully stored for analysis in the TWAD Board, Chennai.

The samples were analyzed for relevant physico-chemical parameters such as pH, total dissolved solids, electrical conductivity, total hardness, calcium, magnesium, sodium, potassium, COD. pH & EC were measured in the field immediately after collection of water samples. All the parameters were analyzed following the procedure specified in APHA (1998).

Water pollution is defined as the presence of impurities in such quantity and of nature as to impair the use of water for a stated purpose. When pollutants enter the water bodies, they get dissolved or lie suspended in water or get deposited on the bed. The water body is able to withstand the pollutants up to certain threshold, beyond which the quality of water deteriorates. The various physico-chemical parameters for different seasons are evaluated and critically analysed.

Results and discussion

Analytical results for water chemicals and COD are provided for pre-monsoon and post-monsoon periods (Table 2 and 3).

Hydrogen ion concentration (pH)

The pH is one of the most important operational water quality parameters as it influences many chemical and biological processes within a water body. In as much as the solubility of carbon dioxide changes with pressure and temperature, so temperature plays an important role in controlling the pH. High pH values (>8.5) are commonly associated with sodium carbonate–bicarbonates waters. Moderately high pH values with waters high in bicarbonates and low values (<4.0) are associated with water containing free acids derived from oxidizing sulphide minerals. Most of the aquatic flora is flourished within the pH value of either side of 7. Rapidly growing algae or submerged aquatic vegetation remove CO_2 from the water during photosynthesis, significantly increasing pH levels.

On perusal of table the pH of the dug wells, tube

Table 2. Average range of physico-chemical parameters in water during the pre monsoon period (June 2008 and June 2009)

	Dug Well		Tube Well		Surface Water	
	Minimum	Maximum	**Minimum**	**Maximum**	**Minimum**	**Maximum**
pH	6.75	8.12	7.08	7.89	7.230	7.580
EC (Microsiemen/cm at 25^0)	1334	4853	1199	7254	536	3237
TDS (Total dissolved solids) (mg/l)	1535	6053	1164	6488	645	4596
TotalHardness in $CaCO_{3(mg/l)}$	1267	331	1273	141	1249	177
COD (mg/l)	206	276	82	269	20.	117

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wells and surface water it is observed that the pH varies from 6.75 to 8.12. This shows that the pH indicates alkaline nature of the water samples.

During the post monsoon period the pH varies from 6.98 to 7.79 and is alkaline in nature in all water samples of dug wells, tube wells and surface water. Thus the alkaline pH is particularly due to bicarbonates. On comparison of pH ranges in different periods like the pre and post monsoon, notable changes are not seen.

The limit of pH value for drinking water is specified as 6.5 to 8. On analysis it is seen that there are variations in the range of pH values in the study area for different time period. This reveals that the pH values are in decreasing trend from more alkaline to neutral with respect to time in the study area. Fresh input of water from precipitation may responsible for the changes have been taken place in the study area.

Electrical conductivity

Specific electrical conductance is a measure of the ability of a substance to conduct an electrical current. It is the reciprocal of the resistance in ohms of a one centimetre column of solution, at a specified temperature, usually at 25° C (Microsiemen/cm at 25° C).

The Electrical Conductivity (EC) has a direct relation with the total solids. In the present study, the EC in the pre-monsoon period varies from 536 to 7254µS /cm and in the post- monsoon period the EC varies from 632 to 6102 µS/cm. During the post-monsoon season there is reduction in EC in the dug wells, and tube wells where as for the surface water an increase is noticed. The EC value for sediment contaminated by waste landfill found to be in the range of 120- 622 µS/cm (Raman 2008).

Total dissolved solids (TDS)

A total dissolved solid indicate the general nature of the water quality or salinity and measures the total concentration of all constituents present in the water. Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates) and small amounts of organic matter that are dissolved in water. These determine the flow of water in and out of the cells of organisms and are essential at certain levels to maintain the aquatic life. High TDS content leads to eutrophication. All species of fish and other aquatic life must tolerate a range of dissolved solids concentrations in order to survive under natural conditions.

The present study reveals that the TDS in the pre monsoon period a varies from 697mg/L to 5306 mg/L with an average of 3162 mg/L in dugwells, 4114 mg/L in tube wells and 2821 mg/L in surface water. During the post monsoon period it varies from 645 to 6488 mg/L with an average of 2621 mg/L in dugwells, 2972mg/L in tube wells and 2460 mg/L in surface water This reveals that data is exceeding the limit prescribed in the CPHEEO, 1999 maximum allowable limit of 2000mg/L . We must keep in mind that in areas like this some of the values observed may be site specific due to local conditions.

Total hardness

During the pre-monsoon period the total hardness is generally high in dug wells, tube wells

Table 3. Average range of physico-chemical parameters in water during the post monsoon period (January 2008 and January 2009)

	Dug Well		Tube Well		Surface Water	
	Minimum	**Maximum**	**Minimum**	**Maximum**	**Minimum**	**Maximum**
pH	6.98	7.64	6.80	7.79	7.28	7.54
EC (Microsiemen/cm at 25^0)	1020	4090	1161	4406	632	6102
TDS (Total dissolved solids) (mg/l)	1316	7859	1148	4573	697	5306
Total Hardness in $CaCO_{3(mg/l)}$	1120	225	250	632	42	420
COD	93	129	31	119	25	129

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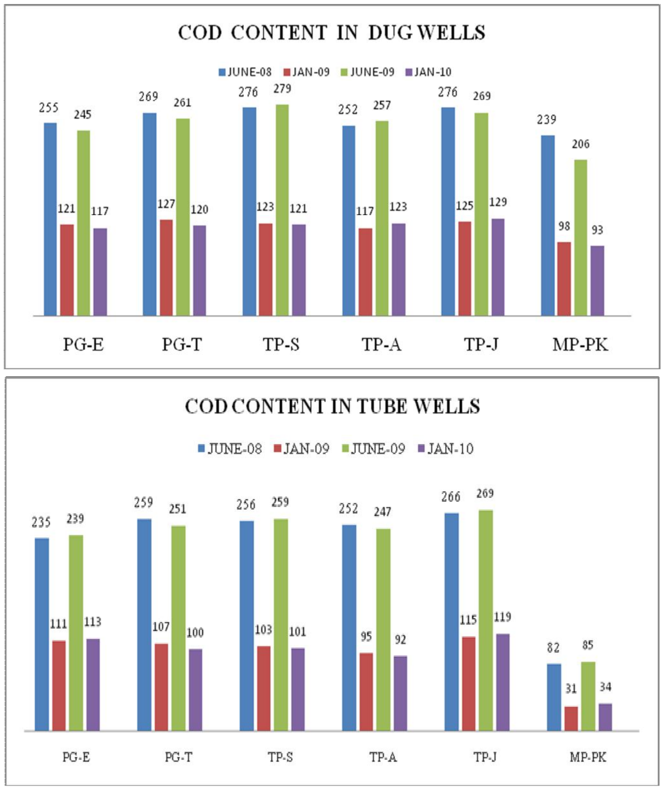

Fig.2 Seasonal variation in COD value in dug wells and tube wells

and surface water (varying between 141-1249) than post- monsoon period 42 to 1120). According to CPHEEO, 1999 the maximum allowable is 600 mg/L and desirable limit is 200mg/L for total hardness. In the pre monsoon period, the total hardness values in the present study exceed the CPHEEO, 1999 the maximum allowable of 600 mg/L and post monsoon period the values exceed the CPHEEO, 1999 desirable limit of 200mg/L.

COD

Chemical Oxygen Demand (COD) is a measure of oxygen equivalent to the organic matter content of the water susceptible to oxidation by a strong chemical oxidant and thus is an index of organic pollution. COD value varies from 20- 276 mg/L in pre-monsoon period and 25-129 mg/L during the post-monsoon period. The COD is high in the pre monsoon season and exceeds the limits prescribed in the Indian Standard 250 mg/L which is the indication of the organic contaminants in the water body. Drinking water should not have oxygen demand and so COD should be Nil (CPHEEO, 1999).

Seasonal variation in dug wells and tube wells during June 2008, January 2009, June 2009 and January 2010 for COD

The extent of contamination of ground water quality due to land fill waste depends upon a member of factors like leachate composition, rainfall, depth and distance of the well from the pollution source. The contaminant concatenations tend to decrease during the post monsoon season and increase during the pre monsoon seasons in most of the samples due to dilution effect. However, in the unprotected land fill sites, due to migration of contaminants from land fill sites, sometimes the post monsoon values might be higher than the pre monsoon values. In some the post monsoon values are high near the land fill sites than the pre monsoon due to the migration effect of contaminant. Temporal variation of the COD and in the ground water from the six locations both for dug well and tube wells from June 2008 to January 2010 are assessed (Table 4).

The COD values in the dug wells during the pre-monsoon and post monsoon periods in June 2008, January 2009, June 2008 and January 2010 was shown that the pre monsoon values are higher than the post monsoon values. The COD values in Thuraipakkam-Shanmugam and Perungudi – Elumalai House is high as they are close to the dumpsite. Whereas, the values in the location Mettukuppam PillaiyarKoil street is low as it away from the dumpsite.

The COD values in the tube wells during the pre monsoon and post monsoon periods in June 2008, January 2009, June 2009 and January 2010 shows that the pre monsoon values are higher than the post monsoon values and is highest in the location Thuraipakkam Jayabalan and is closer to the dumpsite. The values in the location Mettukuppam Pillaiyarkoil Street is low both in pre-monsoon and post post-monsoon season as the location is away from the dumpsite. Similar trend was seen in the dugwells values for COD (Fig.2).

According to Patnaik and Srihari (2004) the water quality in Pallikaranai Marsh showed high

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values of Electrical Conductivity (EC) denoting high pollution levels with increasing salinity. The study also revealed that the pH value ranging from 6.99-7.96.

Vasanthi *et al*. (2008) observed that the characteristics of Perungudi leachate and indicates high values of total dissolved solids, electrical conductivity and chemical oxygen demand. pH values of the leachate varies from 6.8 to 8. During the post monsoon period, the total dissolved solids concentration was reduced but is still found to be at levels higher than the permissible limit. The high value of total dissolved solids is due to the high amount of inorganic material that has leached from the landfill. Total hardness is in the range of 250 to 5,800 mg/l and exceeds the permissible limit in most of the locations. The high value of chemical oxygen demand indicates the presence of organic matter.

Bhanuraman and Madhavan (2011) observed in the ground water of Perungudi area, in Pallikaranai Marsh, that the concentration of ammonia in the water quality samples are high enough to cause irritation to eyes, nose and throat of the most sensitive individuals.

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