International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 02 Issue: 06 | Sep-2015 www.irjet.net p-ISSN: 2395-0072

Monsoon effects on abandoned and active dumping sitesat Pondicherry

V.JOTHI[1], K. RAVIKUMAR[2*], ASHUTOSH DAS[1]and MUKESH GOEL[1]

1 Centre forSustainable Development, PRIST University, Thanjavur, TamilNadu, India

2 Associate Professor, Department of Civil EngineeringVNR VJIET, Bachupally, Hyderabad, Telangana, India

---

Abstract: Handling municipal solid waste by the growing urban areas is one of the major problems especially in the populated country like India. As the waste quantity is increasing at an alarming rate, the solid waste management is becoming a big challenge to the engineers. In this paper, a case study of monsoon effects on the dumping yards, the leachate that contaminates the surface/groundwater and the soil quality alterations in the surroundings of dumping yards is done. The two dumping yards (Karuvadikuppam - abandoned &Kurumbapet – active) of Pondicherry city (Union Territory) have been taken for the study. Surface and groundwater samples were collected in three seasons, namely, pre-monsoon, monsoon and post monsoon periods in both the locations for comparison purposes. Similarly, soil samples were collected over entire dumping yard to evaluate the spatio-temporal variation in the soil quality parameters over three seasons. GIS mapping is done using Quantum-GIS. Finally, two-way ANOVA study was carried out using water samples and soil samples to identify the statistical significance between the observed parameters.

Key Words: Municipal solid waste, dumping site, surface/ground water analysis, soil analysis, Q-GIS, spatio-temporal variation, ANOVA and Pondicherry Municipality

1. Introduction

One of the burning problems faced by most of the urban areas is the management of the solid waste, being incrementally aggravated by rapid growth of population and urbanization[1]. The most commonmethod of disposal of municipal solid wastes, especially, in developing countries includesdumping, sanitary land fill, incineration and pyrolysis, which have their own set of limitations[2 & 3]. Only developed countries could invest from initial to final stage including entire operation of the methods of land filling and incineration. On the other hand, developing countries could adopt the open dumping method mainly due to its simplicity and low cost. India's traditional way of disposing solid waste had been the open dumping method, which are in 2020 number or at sea[4].

As far as Municipal Solid Waste (MSW) is concerned, along with land degradation (loss of soil fertility and contamination of surface/ groundwater) there are other locally arising problems likerodent menace, flies and odors nuisances, contamination of even air and so forth. Furthermore, the production and composition of MSW have changed substantially in recent years because of the change in cultural, traditional, socio-economic setup of people (life style), and additionally, long term natural changes such as seasonal variations and climatic conditions may effects the dumping yards[5].

The total MSW generation in all the states of India is accounted (during 2009-2012) as 1,27,486TonsPer Day(TPD) out of which 89,334 TPD was collected and the quantity of 15,881 TPD was only treated[6] before disposal.The purpose of this work is to study the effect of monsoon on surface and groundwater sources and to evaluate the spatio-temporal variation of soil quality in the vicinity of dumping yards of Pondicherry city, one of the Union Territory of India.

2. Study Area

TheUnionTerritoryofPondicherry is spread in an area of 492Sq.kmwhichconstitutes ofthefourerstwhileFrenchestablishmentsofPondicherry(293Sq.kms),Karaikal (160Sq.kms),Mahe(9Sq.kms) andYanam(17 Sq.kms), which are situated at different geographical locations isolated from one another. Pondicherry region, which is the largest of all the four, lies on the east-coast, consisting of 12 scattered areas lying in between 11° 42' to 12° 30'N and between 76°36' and 79°53' E[7].

The population of the Union Territory of Pondicherry has increased from 2,58,561 to 9,74, 340 during 1961to 2010. It has a population of 1,244,464 persons according to 2011

census [8 & 9].In general, paddy is the main crop grown in Pondicherry. Sugarcane and groundnut are the other two major crops grown in Pondicherry(primarily irrigated by Tube wells and Irrigation tanks). Presently, there are about 5,000 small, medium and large scale industries existing in Pondicherry region and it is assessed that 7.02 MCM of ground water resources is consumed per year.
Pondicherry receives an average annual rainfall of 1,200 mm; 70% of which is being ascribed to North-East monsoon (October to December).The climate is tropical with 40°C as highest temperature and around 22°C as minimum temperature. In general, the climatic condition is highly favorable for crop production. Pondicherry city has been experiencing enormous and rapid urbanization at the rate of 6% per annum due to development of Industries, Educational Institutions, better infrastructural facilities, migration of laboretc.[10]

Pondicherry region lies discontinuously at the tail end of two river basins viz., River Gingee and Ponniar. The Gingeeriver(starts at Malayanur hills in Villupuram District of Tamil Nadu) traverses the region diagonally from North-West to South-East and ultimately joins the Bay of Bengal. There are 84 irrigation tanks in Pondicherry regions with a total water holding capacity of 46 MCM. In pre-Independence days, these tanks were the main sources of irrigation. An area of 8,500 Ha was under irrigation by tanks in 1930. It is estimated that after rehabilitation of 84 tanks, 75 MCM of water could be stored and used for irrigation which would substantially increases the area under irrigation by surface water and decrease the utilization of groundwater, which is over exploited at present.

Groundwater is the main source for irrigation, drinking and industrial needs. In this region, there are three major aquifer systems namely Alluvium, Cuddalore Sandstone and Vannur-Ramathapuram Sandstone. Besides these aquifers, Ottai granular zones and KadaperikuppamLimestone also contribute groundwater to some extent.As per the report of CGWB and estimated in 2004, the total annual groundwater draft for all purposes is 137.69MCM[10].

In general, it is found that the water levels are declining gradually due to over exploitation of groundwater for agriculture and other purposes, disturbances in monsoons and non receipt of water in surface water reservoirs.
The excess rainfall during 1996 and 1997 has contributed for the recharge potential to groundwater systems but not to the expected levels because of the reduction in the storage capacity of all the surface water reservoirs.In general, quality of groundwater is potable in Pondicherry region with TDS content ranging from 400 to 1000 ppm. In some cases, ground water pumped from cretaceous sandstone is highly mineralized with TDS ranging from 1000 to 1500 ppm. However, due to over extraction of Ground water, the salt water-fresh water interface has extended upto 4 Km inland, with the electrical conductivity exceeding 2000 micro Siemens/cm at 25°C, the TDS exceeded 2000ppm and chloride is more than 500ppm[10].

3. Dumping Sites around Pondicherry City

Solid waste consists of household garbage, commercial solid wastes, construction debris, and biomedical/hospital wastes.The Union Territory now has 42 large, 125 medium and 6,388 small scale units, most of which are located in the Pondicherry region. Since the estates are proximate to residential areas, pollution from the estates affects the quality of the environment in the surrounding region.Metatupalayam forms the biggest of the industrial estates, with both medium and small scale industries comprising leather, electrical, chemical, food processing, rubber and plastic units. It does not have a good drainage system or a treatment plant. The untreated effluents from a general drain (rich in chromium, nickel, lead, copper and iron), which further combines with the sewage from the nearby residential areas. The effluents are carried into open lands and residential areas during the rainy season and also infiltrating into ground water table. Sedarapet, the second major industrial estate of the Union Territory, is also poorly organizedwith regard to proper drainage, ends up in draining to the low lying areas and ultimately to ponds, whose water is used for agriculture by adjacent villages. Moreover the bird and fish population is affected by the effluents. Thus the industrial pollution from the estates and other locations has begun to affect the quality of the air, water and land and therefore the quality of life of the surrounding region.

Apart from the industrial waste, about 190 tons per day of municipal solid waste (MSW) is generated in Pondicherry and about 120 tons per day in Oulgaretmunicipality[11]. Wastes are currently dumped in low laying areas. PASIC, an autonomous public sector corporation has started to produce compost on a small-scale with the household garbage. Besides, nearly 1 ton per month of biomedical waste is generated in the Pondicherry region. Due to Non–segregation of wastes, some hospital wastes get mixed up with domestic wastes. In fact, 73 per cent of the health care establishments are disposing their wastes within the hospital premises while the rest of the wastes send to the municipality. There are several small clinical units and

laboratories who dispose their wastes with household wastes, which are dumped in low lying areas.

There are two dumping sites around the city, namely Karuvadikuppam (in North-West of city) which is no more activeafter year 2010 and Kurumbapet (in South-West of city) which started in the year 2010. At least three-quarters of the total waste generated per dayfrom the city is dumped at these sites without proper treatment. Fig. 1 shows the locations of two landfill sites.

4. Materials & methods:

4.1 Collection of samples:

4.1.1 Collection of water samples and analysis:

The water samples (both surface and ground-water) were collected at two dumping yards of Kurumbapet and Karuvadikuppam during pre-monsoon, monsoon and post-monsoon periods (during the year 2010). The water samples collection locations are shown in Fig 2. The parameters studied include: turbidity, conductivity, pH and total dissolved solid (TDS) using Water Analyser; alkalinity (both phenopthalene& methyl red) as $CaCO_3$ and total hardness by titrimetric method (as per APHA-2005); Ca, Mg, Na, and K using flame-photometer; Fe using spectrophotometer and Chloride, Sulfate, Nitrate andFluoride using ion-analyzer.Fig 3 depicts the analysis of various surface/groundwater quality parameters of Karuvadikuppam site and fig 4 depicts the analysis of various surface/groundwater quality parameters of Kurumbapet site.

4.1.2 Collection of Soil Samples and analysis:

Soil samples were collected at 12 locations at each site (i.e., Kurumbapet and Karuvadikuppam) during the pre-monsoon, monsoon and post-monsoon periods of the year 2010. Six locations in the interior regions and six locations in the exterior regions from each dumping yard were selected. The soil samples collection locations are shown in Fig 2. The parameters studied include: pH, electrical conductivity (EC), nitrogen (N), phosphorus pentoxide (P_2O_5) and potassium oxide (KO) (as per APHA-2005).

4.2 GIS Mapping:

4.2.1 Base Maps preparation and features identification:

Two separate base maps were prepared using Google Earth by selecting four locations (for latitude and longitude) around the study areas of Karuvadikuppam and Kurumbapet solid waste dumping sites on the North-West and South-West of Pondicherry city. Polygon feature was used for preparing boundaries of the dumping sites and point feature was used for identifying the locations of soil sample stations as well as water sample collection points on the two base maps. Total of 12 sampling stations (on each dumping site) were identified by the method of Delimited text layer provided in Q-GIS 2.0 and simultaneously all the five soil properties (non-spatial data of pre-monsoon, monsoon and post-monsoon) were also added to the point features as an attribute values.

4.2.2 Development of spatial distributions of soil properties:

Using Inverse Distance Weighting (IDW) method, interpolating surfaces were generated for soil properties of pH, EC, Nitrogen, P_2O_5 and KO. Using each dumping site boundary layer, these raster layers were clipped off to get the spatial distribution of each soil property within the boundary of each dumping site. Fig 5 - 10 depicts the spatial distribution of soil properties for Karuvadikuppam and Kurumbapet dumping sites.

4.3 Statistical Analysis of the Significance:

Using the values obtained during pre-monsoon, monsoon and post-monsoon, the test of significance was carried out, using ANOVA (through Analysis Tool Pack add-in for Excel).

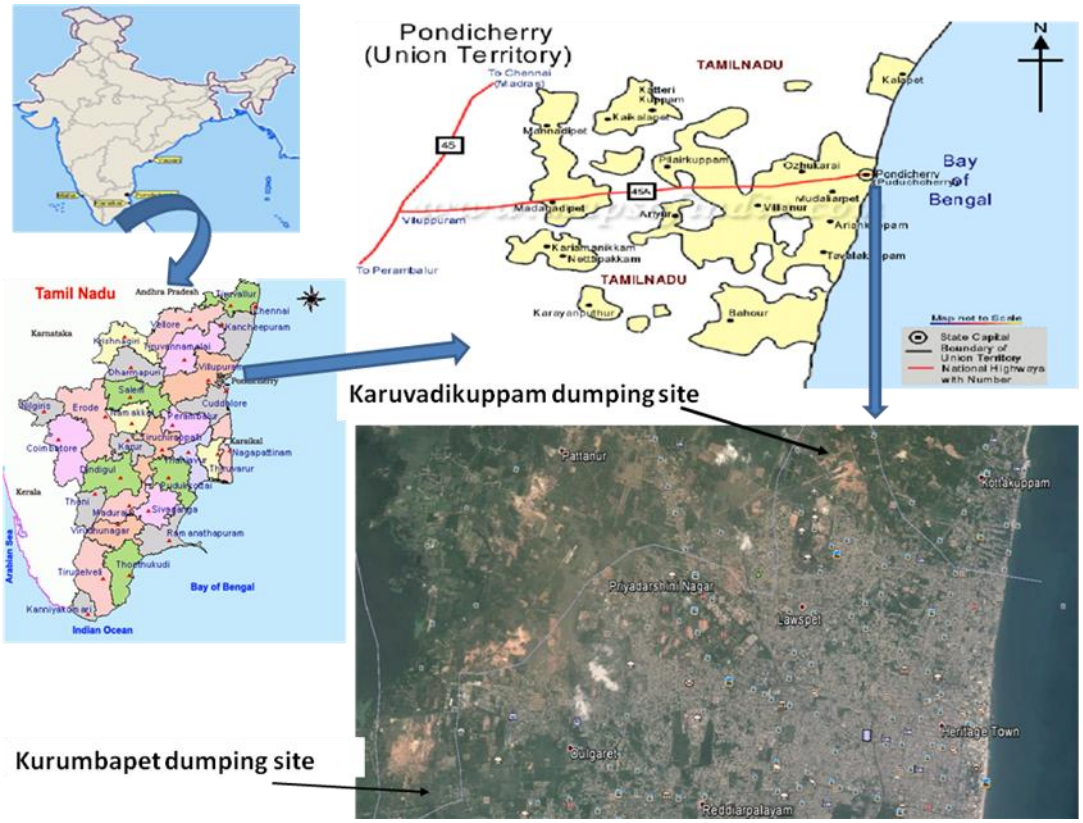

Fig 1: Study area of Solid Waste Dumping sites of Pondicherry

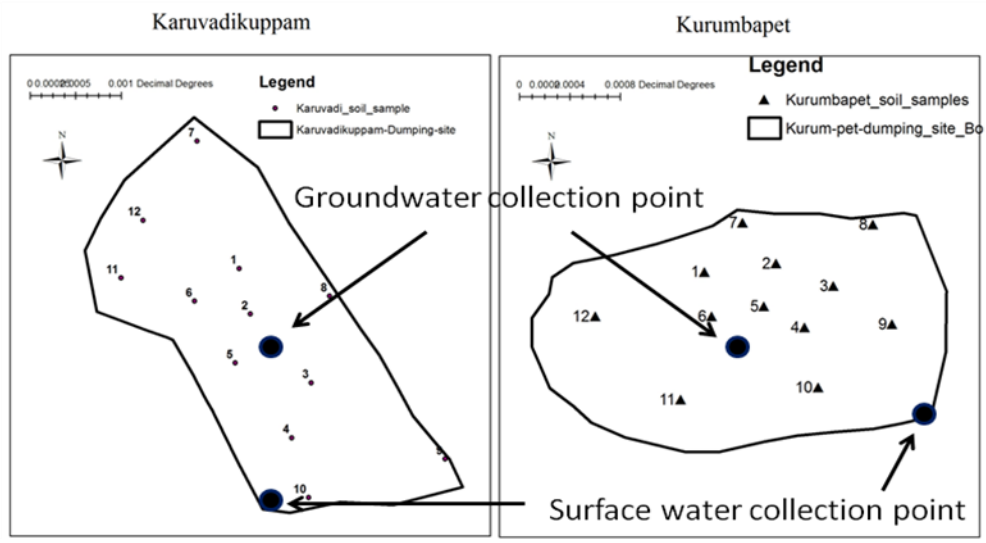

Fig 2: Two solid waste dumping yards of Pondicherry and their surface/groundwater collection point

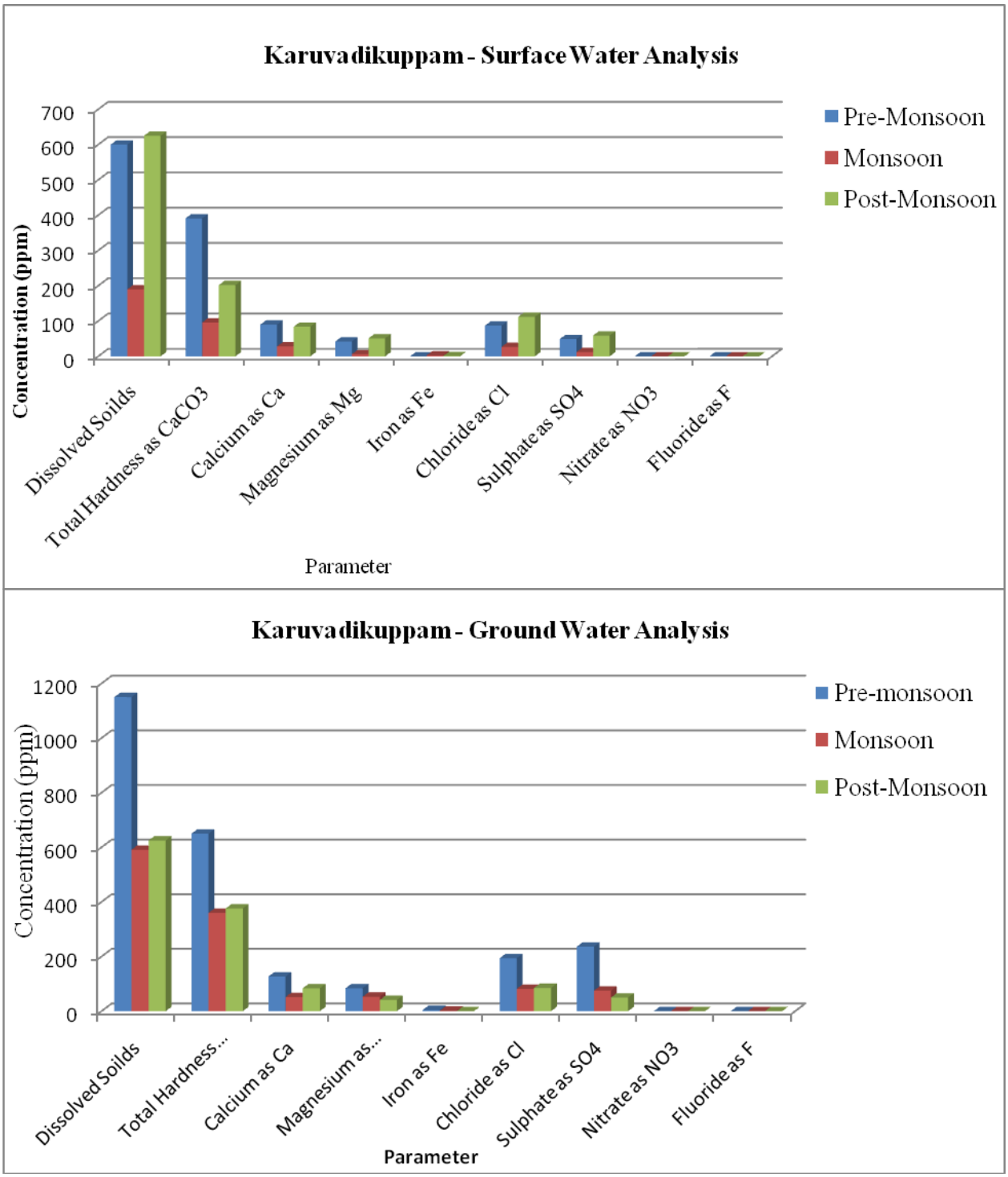

Fig 3. Karuvadikuppam surface/groundwater analysis

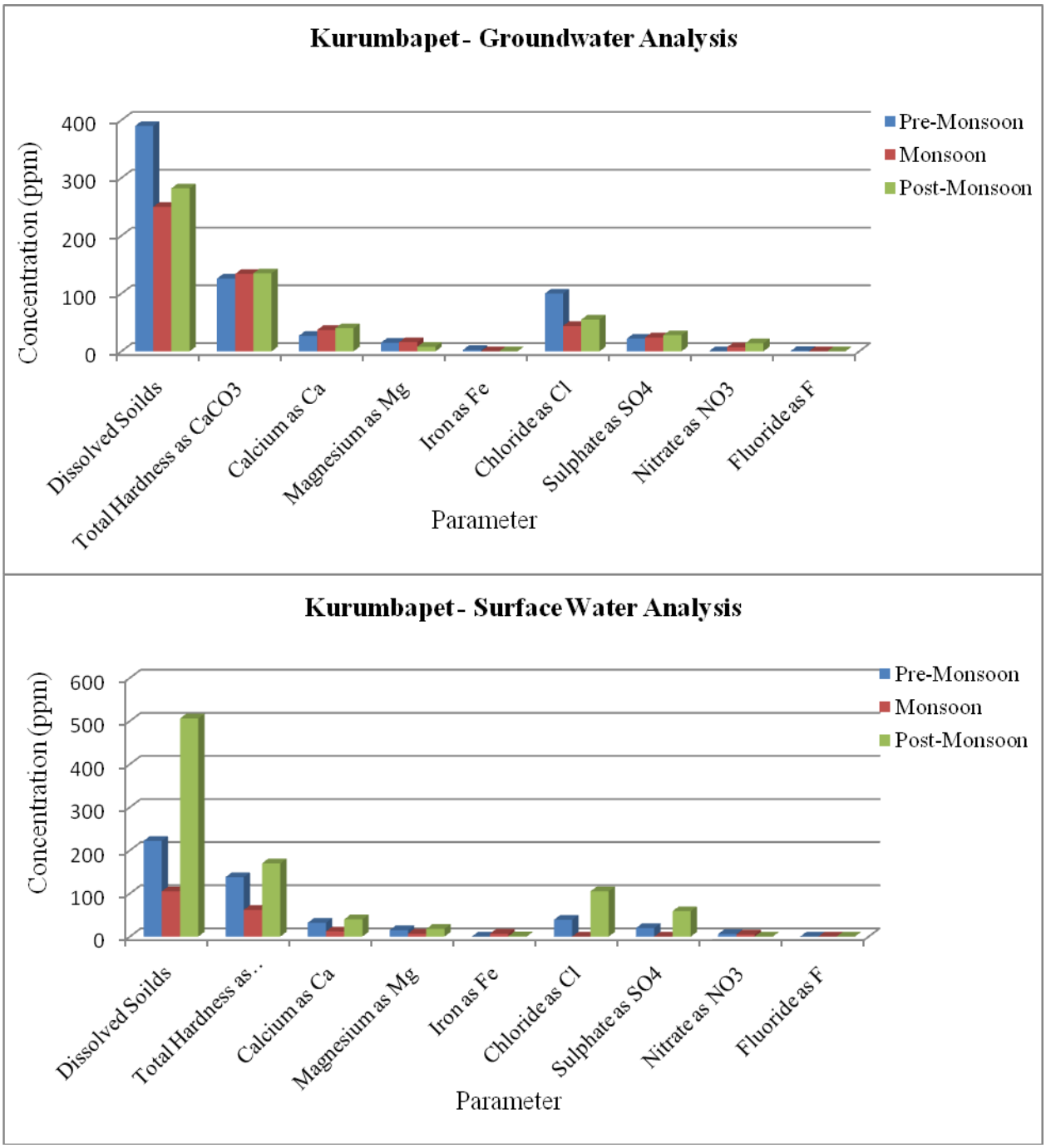

Fig 4. Kurumbapet surface/groundwater analysis

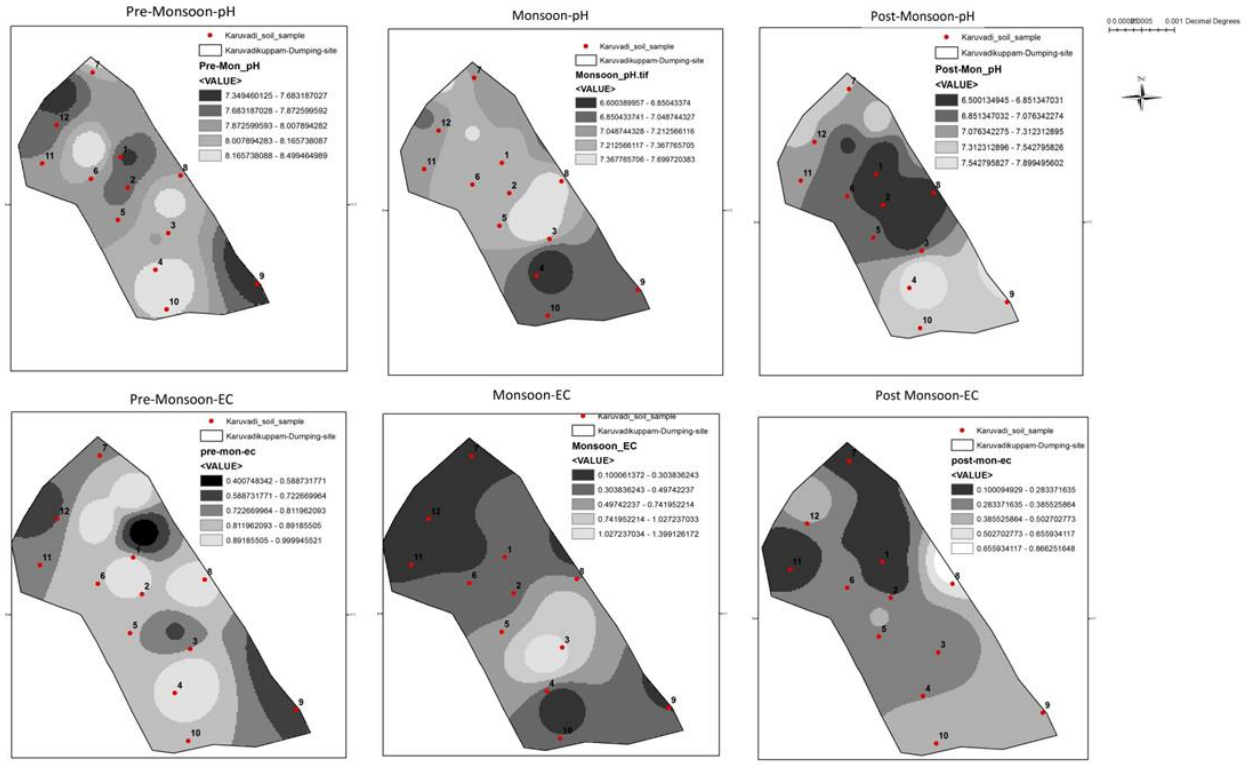

Fig 5: Soil quality parameters (pH and EC) spatial distribution at Karuvadikuppam dumping site

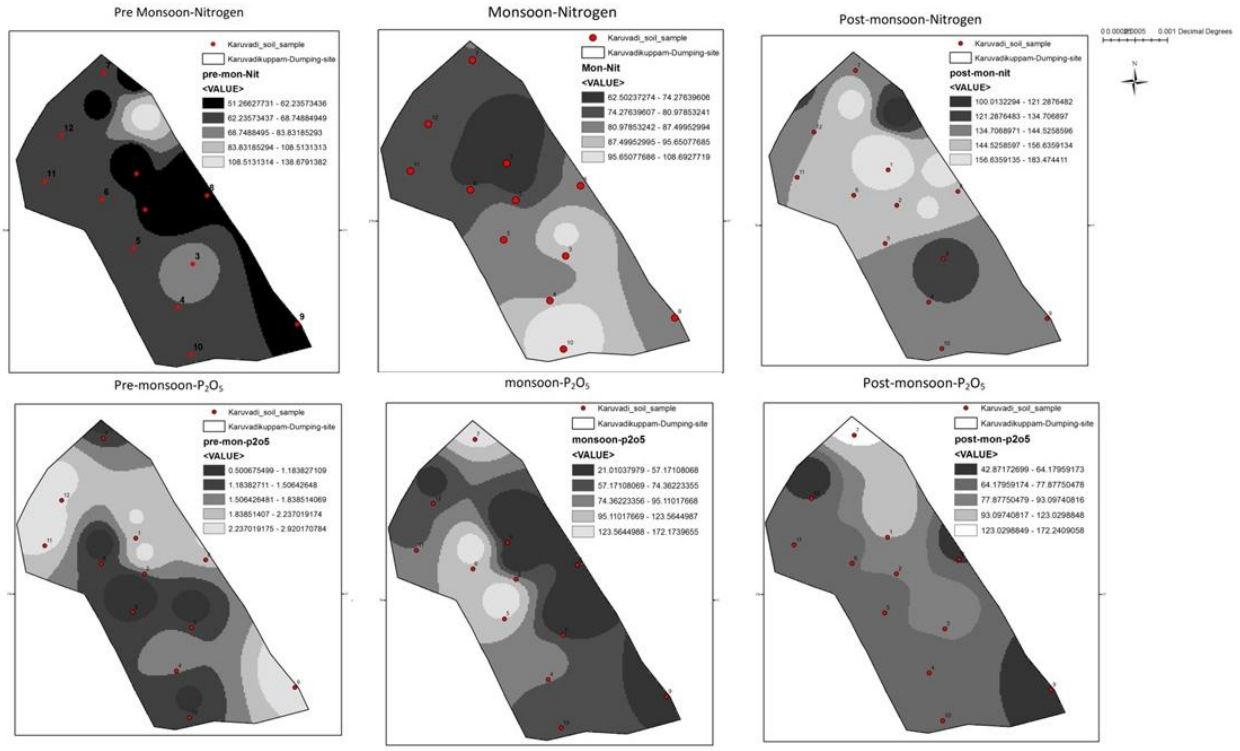

Fig 6: Soil quality parameters (N and P_2O_5) spatial distribution at Karuvadikuppam dumping site

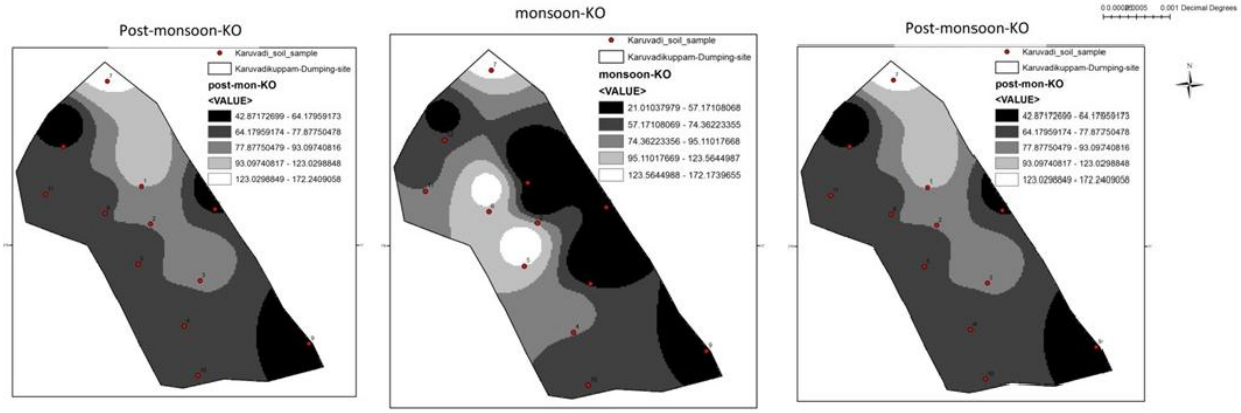

Fig 7: Soil quality parameter (KO) spatial distribution at Karuvadikuppam dumping site

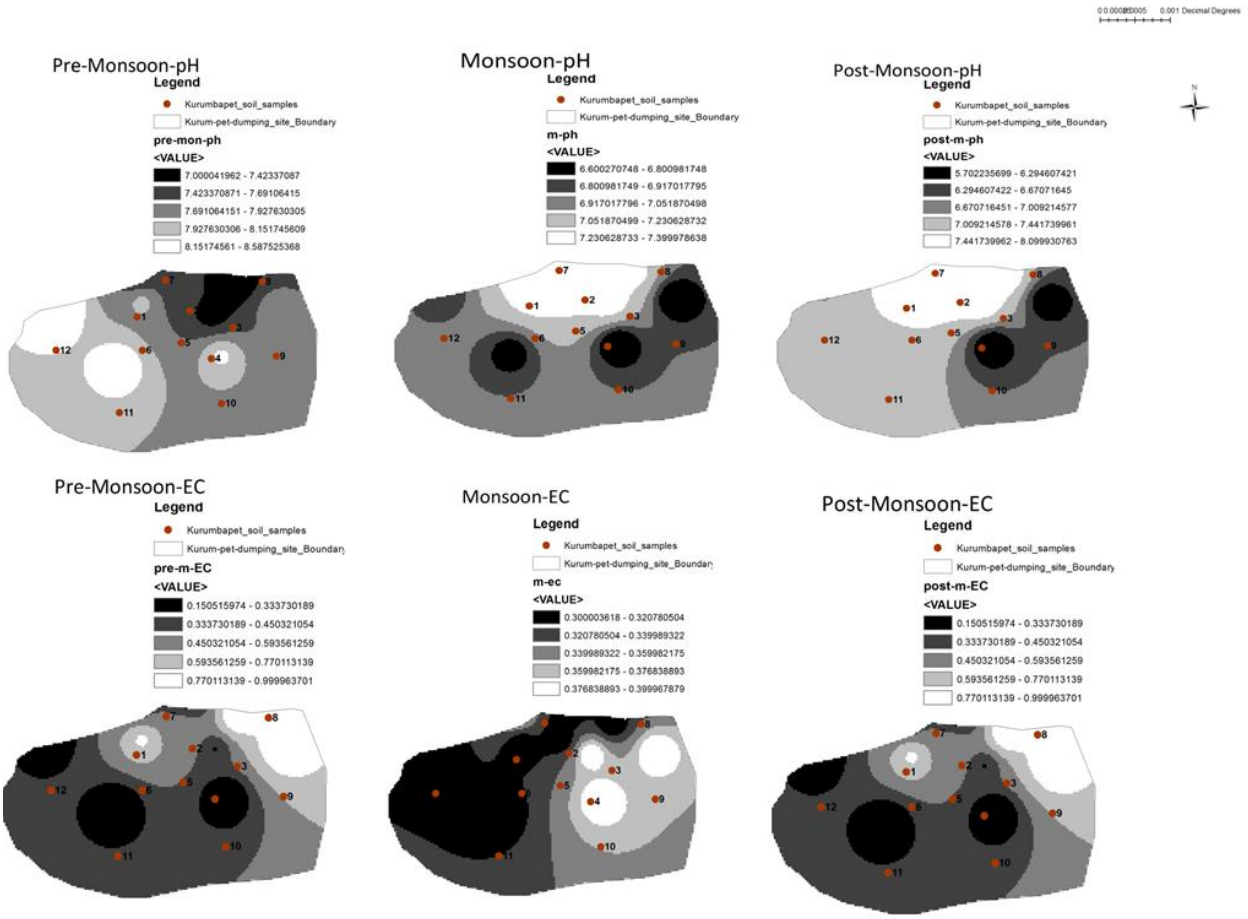

Fig 8: Soil quality parameter (pH and EC) spatial distribution at Kurumbapet dumping site

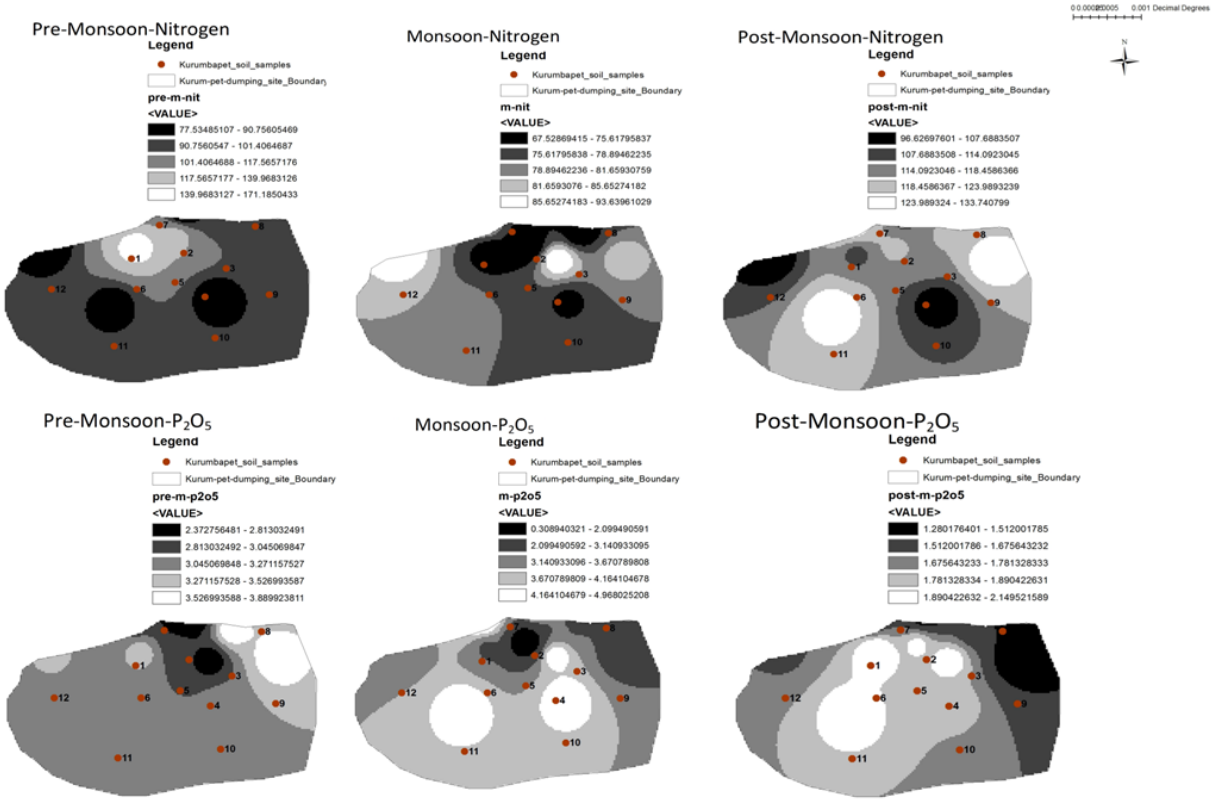

Fig 9: Soil quality parameter (N and P_2O_5) spatial distribution at Kurumbapet dumping site

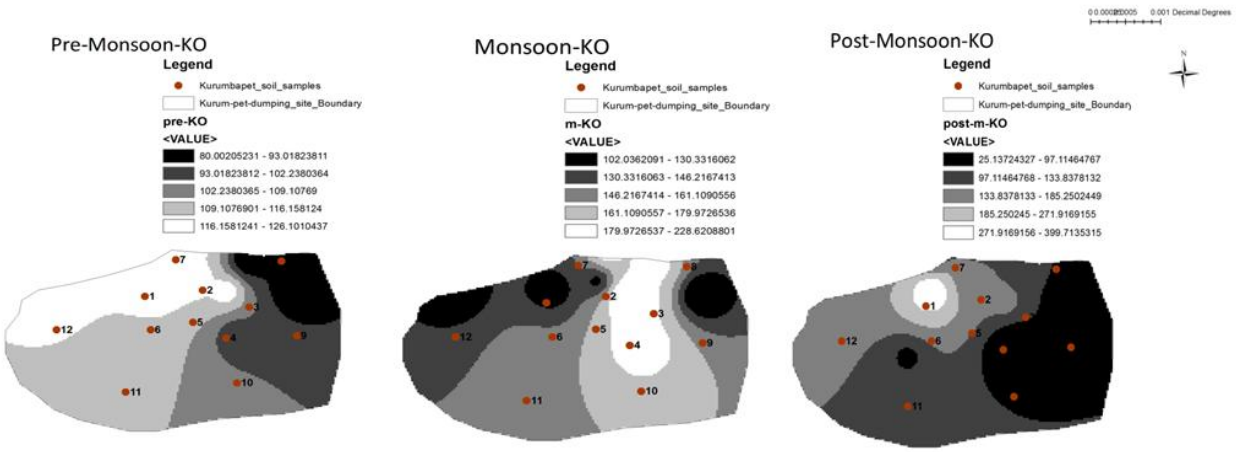

Fig 10: Soil quality parameter (KO) spatial distribution at Kurumbapet dumping site

Table 1: Comparison of soil quality parameters at two dumping sites

Parameter	Karuvadikuppam	Kurumbapet
pH	Monsoon neutralized pH values over entire site from higher pH to lower pH (8.499 to 7.699). Again in post monsoon season, pH values gradually increased to 7.89.	Similar to Karuvadikuppam, monsoon has the effect of decreasing (neutralizing) pH values over entire land fill site. Again in the post monsoon season, pH values gradually increased.
EC	Monsoon increased EC values of central part of the land fill site whereas rest of area, EC remains the same.	Monsoon has decreased the EC values of half of the left portion of the dumping site whereas monsoon has increased EC values of half of the right portion of the dumping site.
Nitrogen	Monsoon decreased the measured maximum concentration of Nitrogen from 138.7 mg/lit to 108.7 mg/lit in the central portion of the site whereas measured lower concentration is increased from 51.27 to 62.5 mg.lit in the Northern part of the site.	Monsoon decreased the Nitrogen concentration from 171.85 to 93.63 mg/lit in the Northern parts whereas again in post monsoon season, the Nitrogen concentration is increased to 133.75 mg/lit. On the other hand, minimum values of 74.5 mg/lit is further decreased to 67.52 mg/lit in monsoon season. From pre-monsoon to post-monsoon, there is over all increase of Nitrogen all over the site.
P_2O_5	Monsoon increased concentration all over the site from 5.92 to 172.73 mg/lit and it is further continued in post-monsoon season also. Over all site is having the concentration range from 21 to 172 mg/lit in monsoon and post monsoon seasons.	Monsoon brought random changes all over site. Compare to Karuvadikuppam dumping site, maximum concentration is much low (i.e varied from 2.15 to 4.96 mg/lit) anywhere in the site.
KO	Monsoon does not have much effect on KO concentrations all over the site.	Monsoon increased maximum concentration from 126.1 to 228.62 mg/lit and it further increased to 399.71 mg/lit in post-monsoon season. Overall, KO concentration has increased from pre-monsoon to post-monsoon all over the site.

5 RESULTS AND DISCUSSIONS

5.1 Variation of Water quality:

Both surface water and Groundwater analysis results are presented to know pollutant concentration potential. Pre-monsoon, monsoon and post-monsoonperiods data of the year 2010 were compared between Karuvadikuppam and Kurumbapetdumping sites and evaluated based on the standards of Bureau of Indian standards for water supply.

Karuvadikuppam: As indicated in the figure 3,except Chloride the Groundwater quality parameters of pre-monsoon period (such as Total Dissolved Solids (TDS), Total Hardness (as $CaCO_3$), Calcium, Magnesium, Iron, Sulfate, Nitrate, and Fluoride) of Karuvadikuppam land fill site are more than the desirable limits designed by BIS. Monsoon has brought down these concentrations by diluting the pollutant concentrations. Even after dilution, the concentrations of TDS, Total Hardness, Mg and Iron remained above the desirable limits set by BIS. As indicated in figure 4, the surface water quality parameters (such as Total Dissolved Solids (TDS), Total Hardness (as $CaCO_3$), Calcium and Magnesium) of Karuvadikuppam land fill site are more than the desirable limits designed by BIS. Monsoon has decreased these concentrations to within the limits by diluting them whereas the concentrations of the Iron, Sulfate, Nitrate, and Fluoride are within the limits of BIS in the pre-monsoon period itself and they further reduced in monsoon period.

One remarkable observation in the surface water quality parameters when compared with groundwater quality parameters is that in the post-monsoon period the parameters of Calcium and Magnecium have increased to the previous status that was prevalent in pre-monsoon season. Whereas, the concentrations of TDS and Total Hardness have increased more than the pre-monsoon period values. This can be interpreted due to the leachate infiltration into the groundwater has reduced in the post-monsoon period compared to pre-monsoon period.

Kurumbapet: As indicated in the figure 5,except Iron, the Groundwater quality parameters of pre-monsoon period (such as Total Dissolved Solids (TDS), Total Hardness (as $CaCO_3$), Calcium, Magnesium, Sulfate, Nitrate, and Fluoride) of Kurumbapet land fill site are within the desirable limits of BIS for water supply. Although monsoon has reduced the Iron concentration to near to its desirable limit value, the concentration of Nitrate has increased in the monsoon and post-monsoon periods. As indicated in the figure 6,except Nitrate, the Groundwater quality parameters of pre-monsoon period (such as Total Dissolved Solids (TDS), Total Hardness (as $CaCO_3$), Calcium, Magnesium, Sulfate, Iron and Fluoride) of Kurumbapet land fill site are within the desirable limits of BIS for water supply. Monsoon period could reduce the Nitrate concentration to near to its desirable limit value and the concentration of Iron has increased in the monsoon period and educed during post-monsoon period.

Similar to the observation done in Karuvadikuppam landfill site, the parameters of TDS, Total Hardness, Calcium, Magnesium, Chloride and Sulfate are increased (in post-monsoon period) to more than its values in pre-monsoon period. The similar reasoning can be given here that the leachate infiltration into the groundwater has reduced in the post-monsoon period compared to pre-monsoon period.

5.2 Spatial Analysis of Soil Quality

The 36 soil samples (from each dumping site according to three seasons) were tested in soil testing laboratory of PASIC (A Govt. of Puducherry Undertaking). Soil nutrient results of monsoon, pre-monsoon and post monsoon periods were compared with the critical limit of Indian compost standards and also compared with dumped area data. The observations of soil studies at the two sites are compared and shown in table 1.

5.3 Statistical significance of monsoon effects and surface/ground water:

Using the data obtained from the field, two way (monsoon-pre, during and post monsoon & source-ground/surface water: for monsoon effect and water samples; proximity effect-for soil samples) ANOVA studies was carried out for water samples w.r.t. each of the studied parameter (without replications) and for soil samples w.r.t. studied parameters with replications. The results indicated that the water quality (Total Hardnes as $CaCO_3$) shown statistical significance ($p= 0.026158$ (for monsoon) & 0.015434 (for source)) only for Karuvadikuppam w.r.t. both monsoon as well as source, with 0.05 level of significance. Kurumbapet does not show any significance with regard to any of the said parameters.

Soil sample on the other hand shows variability w.r.t monsoon for the parameters pH and Nitrogen in both the locations with regards to monsoon. Additionally, P_2O_5 and Conductivity shows significant effect for Karuvadikuppam and Kurumbapet, respectively. With regards to proximity, there is significance variation in pH and K_2O for Karuvadikuppam and P_2O_5 for Kurumbapet. Besides, pH

was found to show significant monsoon proximity interaction in both the locations.

CONCLUSIONS

In this study, the soil samples (12 from each site) and water samples (surface as well as groundwater from each site) from different locations of the two dumping sites (Karuvadikuppam and Kurumbapet) in Puducherry were collected during pre-monsoon, monsoon and post-monsoon periods and their physic-chemical parameters were analysed. The GIS surface techniques were employed to understand the spatio-temporal variability of soil and water quality parameters. The physico-chemical properties of soil and water were influenced by solid waste dumping in this area. Chi-Square distribution test using SPSS software for the significance level of hypothesis.

Based on this study, the following conclusions are arrived at:

Soil quality: In both sites, pH values were reduced (neutralized) due to the dilution in the monsoon period and as usual increased in the post-monsoon period due to leachate accumulation in the top soil. EC remains unchanged except in center portion of the Karuvadikuppam site due to monsoon. At Kurumbapet, monsoon has decreased the EC values of half of the left portion of the dumping site whereas monsoon has increased EC values of half of the right portion of the dumping site. Monsoon decreased the maximum concentration of Nitrogen in the central portion of the Northern part of the Karuvadikuppam site. Monsoon decreased the maximum Nitrogen concentration in the Northern parts of Kurumbapet landfill site on the other hand there is over all increase of Nitrogen concentration all over the site. Monsoon does not have any effect on the concentration of P_2O_5 all over the site and as the waste dumping more and more, the concentration of P_2O_5 is further increased in post-monsoon season also. As Kurumbapet site is relatively new compare to Karuvadikuppam dumping site, the maximum concentration of P_2O_5 is much low over entire site from pre-monsoon to post-monsoon. Monsoon does not have much effect on KO concentrations all over the site of Karuvadikuppam whereas concentration of KO increased from 126.1 to 399.71 mg/lit at the end of post-monsoon season in the site of Kurumbapet.

Water Quality: In both landfill sites, monsoon period could decrease the concentrations of TDS, Total Hardness, Ca, Mg, Iron, Sulfate, Chloride, Nitrate and Fluoride of the surface water but in the post-monsoon period they were again increased due to accumulation of leachate on the surface. The similar effect of decreasing the groundwater concentrations during monsoon period is observed in both landfill sites but in the post-monsoon period these concentrations were not increased due to low leachate infiltration into the groundwater.

REFERENCE

1. SudhaGoel. Municipal Solid Waste Management in India – A Critical Review, *Journal of Environmental Science and Engg*, Vol. 5(4), 319-328, 2008.
2. Sharma, S., and Shah, K.W. Generation and disposal of solid waste in Hoshangabad. In: *Proceedings of the Second International Congress of Chemistry and Environment*, Indore, India, pp 749–751, 2005.
3. Central Pollution Control Board (CPCB). Management of Municipal Solid Waste. *Ministry of Environment and Forests*, New Delhi, India, 2004.
4. Swapan Das and Bidyut Kr. Bhattacharyya. Municipal Solid Waste Characteristics and Management in Kolkata, India, *International Journal of Emerging Technology and Advanced Engineering*, Volume 3, Issue 2, 147-152, 2013.
5. Adani, F., Scatigna, L., Genevini, P. Biostabilization of mechanically separated municipal solid waste fraction, *Waste Manage Res*, 18, pp 471–477, 2000.
6. Central Pollution Control Board CPCB. Status Report On Municipal Solid Waste Management, *Ministry of Environment and Forests*, New Delhi, India, 2012.
7. Wikipedia. http://en.wikipedia.org/wiki/Pondicherry, 2014
8. R.Rajamanickam and G.Poyyamoli. Towards Zero-Waste Campus: Compositional Analysis of Solid Waste at the Staff Quarters to frame Inclusive Sustainable Campus Waste Management System, *International Journal of Innovative Research in Science, Engineering and Technology*, Vol 3(4), 11255-11264, 2014.
9. Puducherry Profile. Census of India website. [Online]. Available: censusindia.gov.in/ 2011census/.../profiles/en/IND034_Pondicherry.pdf, 2011.
10. Water Year, Groundwater Brochure, Puducherry Region, U.T. of Puducherry, CGWB, Ministry of Water Resources, Government of India, 1-26, 2007.

11. Swati Pattnaik and M. Vikram Reddy. Assessment of Municipal Solid Waste management in Puducherry (Pondicherry), India, *Resources, Conservation and Recycling*, Volume 54, Issue 8, 512–520, 2010.