SPATIAL ANALYSIS OF GROUND WATER CONTAMINATION IN CLOSE VICINITY TO SOLID WASTE SITES IN FAISALABAD USING GIS TECHNIQUES (A CASE STUDY)

Mariam Kareem[1], Muhammad Nasar u Minallah[2], Nusrat Parveen[1] and Syed Ali Asad Naqvi[3]

[1.] Department of Geography, GC University Faisalabad, Pakistan

[2.] Department of Geography, Govt. Postgraduate College Gojra, Pakistan

Department of Geography, GC University, Lahore, Pakistan

Corresponding Author: Nasarbhalli@yahoo.com

ABSTRACT: *Emergence of industrialization and Urban sprawl are forceful factors in raising the graph of water contamination in Faisalabad, the 2nd largest industrial city of the Pakistan because of heavy metals and various pollutants into the urban environment. An experimental work has been conducted to analyze the heavy metals SAR, RSC, Pb, Ni, turbidity, PH, EC and Cd with the help of ICP in the ground water of the urban area of Faisalabad City. A simple random sampling technique was applied from the near distance of 10 meters to a maximum distance of 200 meter from the solid waste sites. Laboratory analysis andgeo-statistical technique (Universal Kriging) was applied to assess the concentration of heavy metal contamination in water along with spatial distribution. The study reveals that the water present in the vicinity of dumping sites is not pure. A large quantity of heavy metal present in water, which is unhealthy for human consumption. The mean concentration of EC, PH, Pb, cd, Ni, RSC, SAR and turbidity ranged from 0.45–33.51, 7–8.7, 0.09–11.09, 0–0.07, 0.01–0.087, 0–32.86, -4.44–42.11 and 39–220 mg/L respectively. It is essential to monitor the water contamination for the ground water quality assessment and sustainable development of the urban environment.*

Key words: Universal Kriging, water contamination, GIS, Faisalabad

1. INTRODUCTION

The geographic Information System has proved itself as the most suitable tool to examine the complex reality of this real world in an easy and systematic way as it provides a significant environment to deal with a great variety of real world phenomenon. The geospatial technology, ranked at 3rd most emerging technology of the world after nanotechnology and biotechnology [1] is very useful for the spatial assessment of any kind of phenomenon. The developing countries are suffering from the urban swelling due to increased rate of migration in the urban centers consequently; the graph of municipal solid waste production has risen from The last few decades. For the management of municipal solid waste, land filling is a common and cheap method which is in practice of many developing countries as well as developed ones [2, 3, 4, 5]. One of the major threats to groundwater is Land filling [6, 7]. This land filling of solid waste leads to the soil pollution and the leachate process contaminate the ground water so, the scale of threat of water contamination with heavy metals is getting large. The land filling method is known as a major threat to the ground water [6, 7].

Water that leaches through dump site induces ground water pollution, as it percolates those elements that are produced due to the biochemical, organic and inorganic processes taking place around the dump sites at Shah Road city in Iran [8]. Forty three physio-chemical ground water parameters were collected from the dump sites and concentration of these parameters exceeding than the permissible limits of drinking water quality and consequently considered as incapable for the use of human in Erode city, Tamil Nadu state of India [9]. In Tanzania solid wastes dump sites have been offering severe problem for the ground water. The concentration of heavy metals is increased in ground water near the dump sites [10]. Increasing of ground water contamination due to the waste yard has become a serious problem. If this problem is not managed properly, the pollutant that percolates through dump waste sites can pollute the ground water seriously [11].

In peri urban areas, the heavy metals are a major menace to the health of human because here the surface water is chiefly used for the irrigation purpose and ground water is used for the domestic purposes. Faisalabad, the 2nd largest industrial city of Pakistan is home to many pollutants, particularly heavy metals into the environment of urban center consequently, there is a great probability that ground water is contaminated due to dumping sites. A huge population of Faisalabad is using this contaminated water which leads to many water borne diseases due to heavy metals like Cadmium, Lead, and Nickel etc. In the developing countries like Pakistan the research on the assessment of soil pollution and water contamination is very limited. There is a strong need to study the soil pollution and water contamination to reduce the losses of human environment and to mitigate the rate of water borne diseases. The present study is a vital step to assess impact of solid waste storage sites on the ground water contamination of heavy metals around the solid waste dumping sites keeping SAR, RSC, Pb, Ni, PH, EC, turbidity and Cd under consideration. The study was focused to analyze the concentration of listed heavy metals in the water. To examine the ground water quality on the grounds of physio-chemical parameters in the vicinity of solid waste sites in Faisalabad. To inquire the ground water contamination around the dumping sites the geospatial statistical methods have been utilized.

2. MATERIALS AND METHODS

This research was based on primary data collection and total 130 sites were selected in the 23 colonies of the Faisalabad. To make this research more authentic and reliable, the technique of simple random sampling was applied while collecting the water samples around the each solid waste site.

The water sample were collected from the houses located near the each solid waste dumping sites and each sample were taken from a distance of 10-200 meters from every solid waste dumping site. Pb, Ni, SAR, RSC, PH, turbidity, cd and EC parameters were selected to investigate the water contamination in the study area and these parameters were examined in Soil & Water Chemistry Lab., Inst. Soil & Environmental Sciences, and UAF. The laboratory work included the utilization of photometer ICP and AAS. The examined parameters were used to prepare to enter in attribute table of ARC GIS 10 and geospatial location of each sample site is located by its latitudes and longitudes find by Magellan GPS. Data were analyzed in Arc GIS 10 by using the geo analyst wizard tools. Cokriging were performed to predict the ground water contamination around the solid waste disposal. The study was twofold, first part was the field and laboratory work and the second part emphasized on desktop work i.e. working with ArcGIS software or statistics.

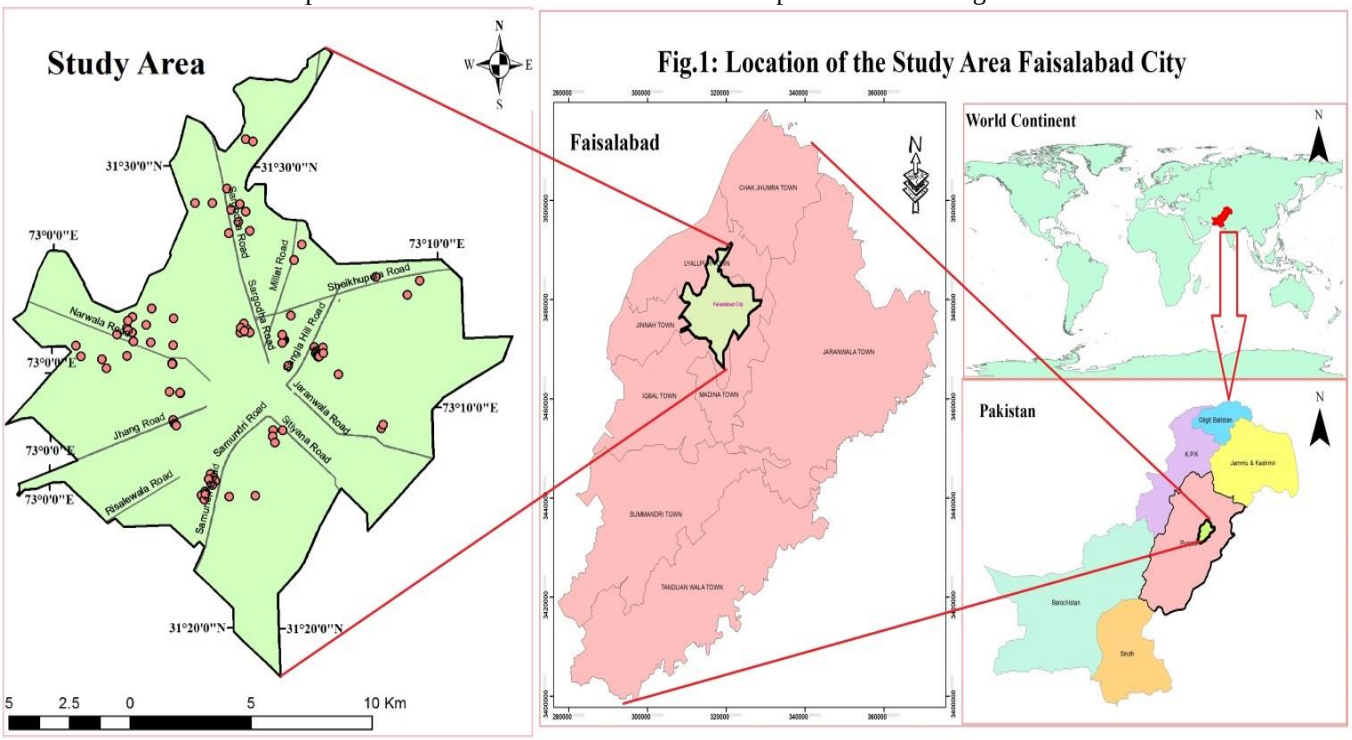

Figure 1: Location of the Study area Faisalabad City

3. RESULTS AND DISCUSSION

The study evaluates the spatial changes in ground water contamination around the solid waste sites by using the Cokriging geo statistical analysis. The Universal Kriging was performed to predict the 127 sample sites and Gaussian and spherical model type were used and prediction performance was analyzed by cross validation. The rate of the Nugget sill can be categorized into different classes according to their spatial dependency. The spatial dependency is strong if the rate of nugget sill is less than 0.25, moderate spatial dependency is between the 0.25-0.75 and the values greater than 0.75 consider as weak dependency [12]. In the Faisalabad city, the rate of spatial dependency classes of nugget sill presented that cadmium; lead, PH and electrical conductivity have strong, nickel and Sodium Adsorption Ratio moderate and turbidity low. In table 2 the predicted error was presented occurred by using the Universal Kriging method in ARC GIS 10

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able 1: Nugget and Sill Rate Pb, Ni, SAR, RSC, PH, turbidity, CD and EC parameters in Groundwater

Element	Model Type	Nugget	Partial Sill	Range	Nugget/Sill Rate
Lead	Gaussian	0.026	26.97	9.984	0.001
Cadmium	Gaussian	0.0001	7.057	0.002	0.00001
Residual Sodium Carbonate	Spherical	36.13	35.81	0.001	1.00
Sodium Adsorption Ratio	Spherical	0.12	17	3.434	0.71
Electrical Conductivity	Gaussian	2.023	16.30	0.00	0.12
Turbidity	Gaussian	0.12	0.04	0.02	3
Potential of Hydrogen	Spherical	0.02	0.10	0.198	0.19
Nickel	Spherical	3.38	8.4	0.003	0.40

Table 2: Prediction errors of the Pb, Ni, SAR, RSC, PH, turbidity, cd and EC parameters in groundwater.

Prediction Errors occurred by using Universal Kriging Prediction Map					
Element	Mean	Root Mean Square	Mean Standardized	Root Mean Square Standardized	Average Standard Error
Lead	0.0001710183	0.01047953	0.02341532	1.015024	0.01027905
Cadmium	0.000553694	0.01569907	0.04132911	1.063527	0.01452259
Residual Sodium Carbonate	-0.151757	7.705404	-0.01146023	0.886619	8.847334
Sodium Adsorption Ratio	0.1376806	11.15984	0.009516432	0.8164722	13.7692
Electrical Conductivity	-0.1687409	3.717292	-0.0301622	1.037785	3.435443
Turbidity	-0.1989306	35.74586	-0.00278553	1.05543	33.93793
Potential of Hydrogen	-0.003980185	0.3719864	-0.01158523	1.124326	0.3297337
Nickel	0.0001710183	0.01047953	0.02341532	1.015024	0.01027905

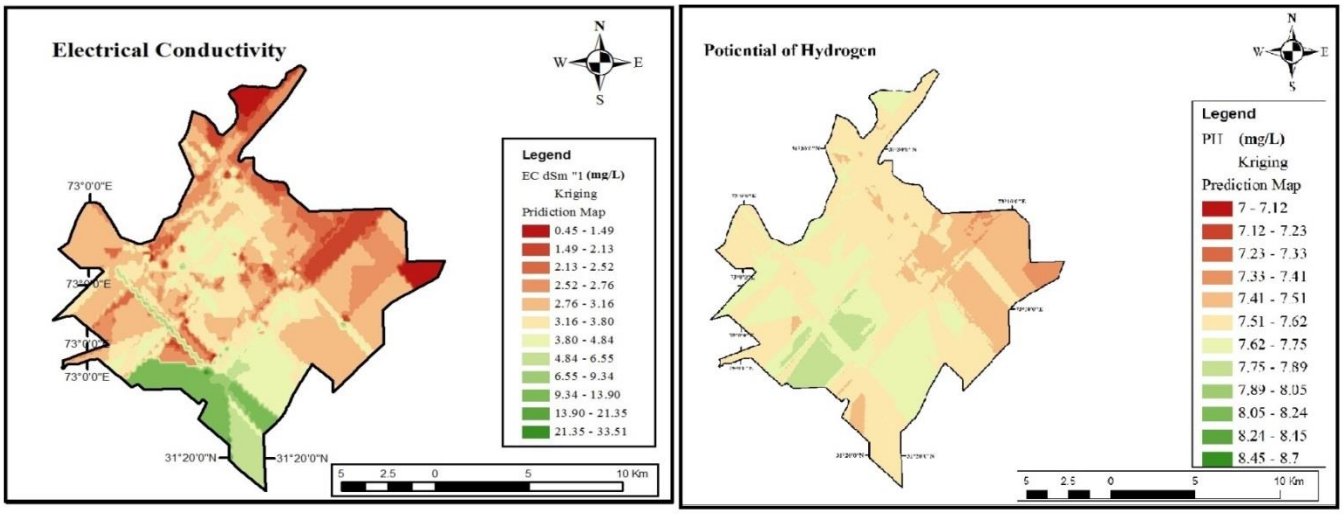

Figure 2: Spatial Distribution of EC and PH in Faisalabad City

The concentration of the parameters of Electrical Conductivity and the hydrogen in water around the solid waste disposal are increasing and continuously polluting the city area. In the northeastern part of the city, the PH quantity is low as compared to the southern, western and north western part of the city area. Ahmadabad, Shrief Pura, Samanabad, Shiekh Colony, G. M. Abad and Ayub colony have the highest quantity of PH above than (8 mg/L). The concentration of electrical conductivity is higher in the southern portion of the city along the Samundari and Jhung road.

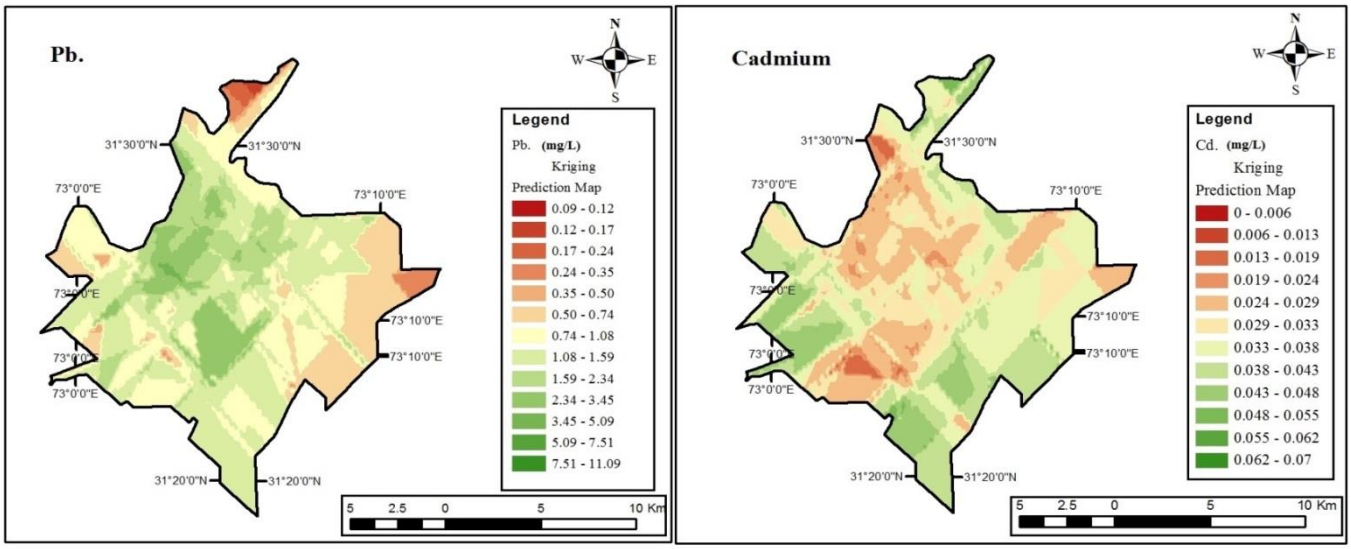

Figure 3: Spatial Distribution of Pb. and Cadmium in the Faisalabad city Area.

In the study area, universal kriging method is used to estimate the lead and cadmium toxicity in the drinking water quality of Faisalabad city. The concentration of lead is high in G.M. Abad, Ayub Colony, Farooqabad, Sharief Pura, D Type Colony and Islamnagar. And the density of Cadmium is higher in the BakarMandi, Muhhala Dan Pura, G. M. Abad, Rassol Nagar, Nishat Abad, Peoples Colony and Aftab Nagar.

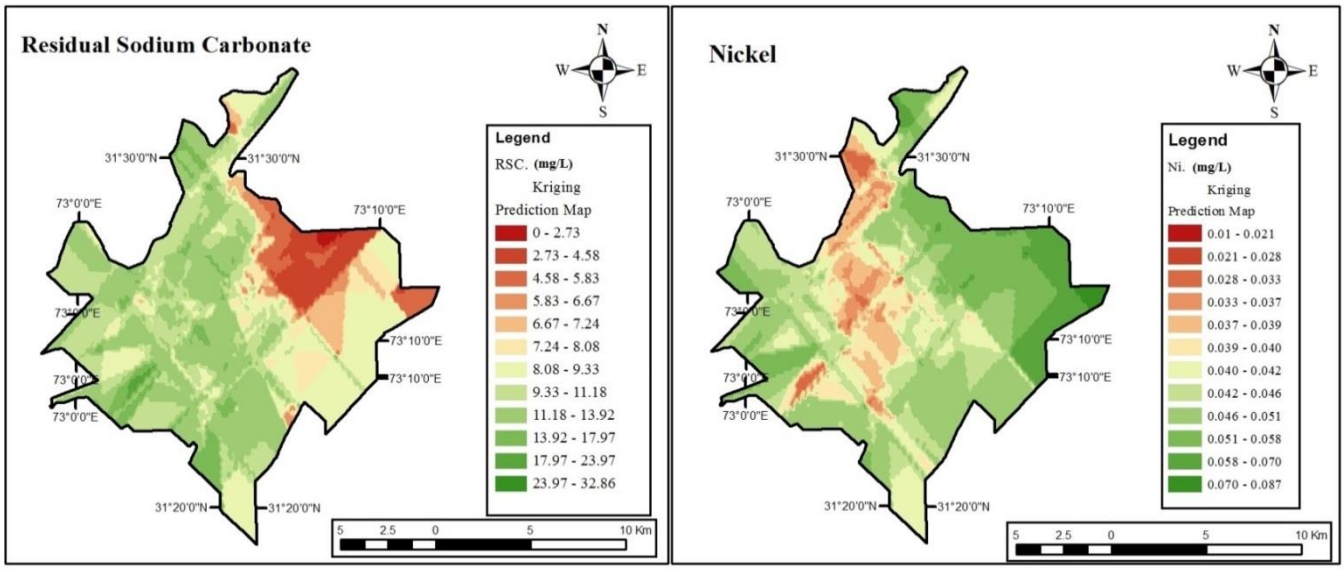

Figure 4: Spatial Distribution of RSC and Nickel in the Faisalabad city

The density of Residual Sodium Carbonate is higher in almost whole of the city expect northeastern area and the toxic amount reached at 32.86 (mg/L). Nickel concentration is high in almost spread in the whole of the city ranging from 0.01 to 0.087 (mg/L).

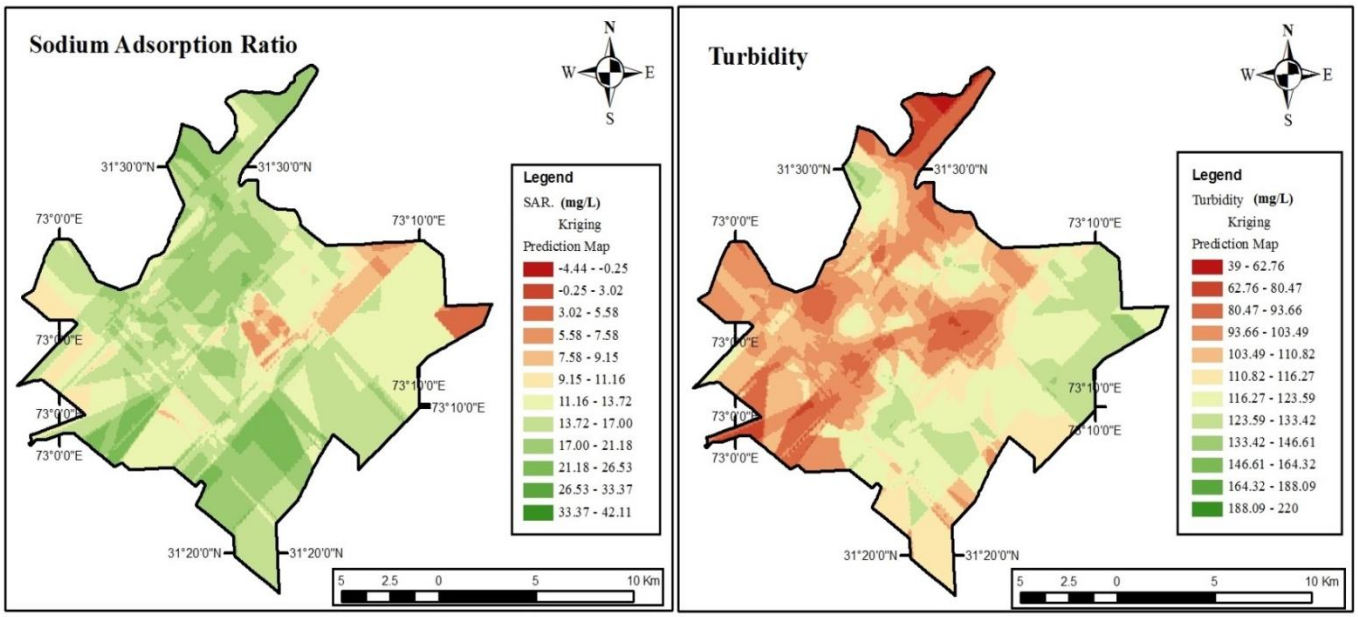

Figure 5: Spatial Distribution of SAR and turbidity in the Faisalabad city Area.

Ratio of sodium Adsorption is higher as compared to turbidity in the Faisalabad city. The amount of turbidity is higher in the eastern and southern portion ranged from 39-220 (mg/L) of the Faisalabad city. The concentration of turbidity is higher in G. M. Abad, Peoples Colony, Rasoolnagar and Muzzaffar Colony. Ratio of sodium Adsorption ranged from -4.44 to 42.11 (mg/L) with the highest concentration in Nanakpura, D-Type Colony, Farooqabad, Samnabad and Nanakpura.

Table 3: Descriptive Statistics of Pb, Ni, SAR, RSC, PH, turbidity, cd and EC parameters in Faisalabad city

Parameters	Minimum	Maximum	Mean	Std. Deviation
Turbidity	39	220	104.05	37.098
Sodium Adsorption Ratio	-4.44	42.11	14.2027	10.12964
Residual Sodium Carbonate	0	38.09	10.2601	8.09022
Lead	0.09	11	1.4932	2.11225
Cadmium	0	0.07	.0293	.01584
Nickel	0.01	0.087	.04280	.012597
Potential of Hydrogen	7	8.70	7.2520	1.61055
Electrical Conductivity	0.45	125	3.9408	10.80107

4. CONCLUSION

It is concluded that all the dumping sites and landfills are a major threat to drinking water. The water samples collected around the waste sites are not fit for human health. The concentration of Physio-chemical parameters SAR, RSC, EC and PH and the heavy metals like Ni, Cd, and Pb are increased to a drastic level that also crosses the WHO standard. It is suggested that the ground water present in the close vicinity of solid wastes should not be used for drinking and irrigation purposes and proper solution to dispose the solid waste should be attempt to assure that this will not pollute the surrounding urban environment. Proper methods should have to be done for waste disposal at industrial and household level. The dispose solid waste can be properly segregated for composting which may be afterward used for fertilizer.

REFERENCES

1. **http://www.dol.gov/eeombd/2005annualreport/preface.htm**
2. El-Fadel M, Findikakis AN, Leckie JO. Environmental impacts of solid waste landfilling. Journal of environmental management. 1997; 50(1):1-25.
3. Daskalopoulos E, Badr O, Probert S. An integrated approach to municipal solid waste management. Resources, conservation and recycling. 1998; 24(1):33-50.
4. Jhamnani B, Singh S. Groundwater contamination due to Bhalaswa landfill site in New Delhi. International Journal of Environmental Science and Engineering. 2009; 1:121-5.
5. Longe E, Balogun M. Groundwater quality assessment near a municipal landfill, Lagos, Nigeria. Research
6. Journal of Applied Sciences, Engineering and Technology. 2010; 2(1):39-44.
7. United States environmental protection agency (USEPA) (1984). Office of drinking water, a groundwater protection strategy for the environmental protection agency, 11
8. Fatta D, Papadopoulos A, Loizidou M. A study on the landfill leachate and its impact on the groundwater quality of the greater area. Environmental Geochemistry and Health. 1999; 21(2):175-90.
9. Mahvi AH, Roodbari A. Survey on the effect of landfill leachate of shahrood city of Iran on ground water quality. Journal of Applied Technology in Environmental Sanitation. 2011; 1(1):17-25.
10. Nagarajan R, Thirumalaisamy S, Lakshumanan E. Impact of leachate on groundwater pollution due to non-engineered municipal solid waste landfill sites of erode city, Tamil Nadu, India. Iranian journal of environmental health science & engineering. 2012; 9(1):1-12.
11. Kassenga G, Mbuligwe S. Impacts of solid waste disposal site on soil, surface water and groundwater quality in Dar es Salaam City, Tanzania. Journal of Sustainable Development in Africa. 2007; 10(4):73-93.
12. Raman N, Narayanan DS. Impact of solid waste effect on ground water and soil quality nearer to pallavaram solid waste landfill site in chennai. Rasayan J Chem. 2008; 1(4):828-36.
13. Uyan M, Cay T, editors. Geostatistical methods for mapping groundwater nitrate concentrations. 3rd international conference on cartography and GIS, Nessebar, Bulgaria; 2010.