International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Hydrochemical Assessment of Groundwater Quality for Drinking in Tamil Nadu's Tirupur District

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Abstract:
Due to the industrialization in Tirupur district of Tamil Nadu in South India, quality of groundwater resources is getting affected. The study aims to assert the chemical composition of groundwater in this area. 15 samples were collected randomly and their latitude and longitude were taken and mapped using GIS. The samples were processed and analysed for various physiochemical parameters such as pH, electrical conductivity, total hardness, dissolved solids and hydro chemical parameter such as calcium, magnesium, chloride, sulphite, chromium, iron. Multivariate statistical analysis provides fundamental insights for finding the chemical composition. Here quality assessment results were compared with the water quality standards prescribed by Bureau of Indian standards (Indian standard specification of drinking water IS: 10500.

Keyword: Industrialization, Physiochemical, Hydro chemical, Water Quality Standards.

1 Introduction

Groundwater is an important natural resource especially for drinking and irrigation uses. Water quality assessment is essential for human health and the definition of water quality depends on the desired use of water (Hoek et al. 2001). Therefore, different uses require different criteria of water quality as well as standard methods for reporting and comparing results of water analysis (Singh et al. 2004).

Groundwater is a vital natural resource. Depending on its usage and consumption it can be a renewable or a non-renewable resource. It is estimated that approximately one third of the world's population use groundwater for drinking purposes (Nickson et al. 2005). Groundwater is the major source of water supply for domestic purposes in urban as well as rural parts of India. The normal groundwaters have typically neutral to slightly alkaline pH dominated by base cations (Ca2, Mg2, Na) and bicarbonate (Frengstad and Banks 2000). Among the various reasons, the most important are non-availability of potable surface water and a general belief that groundwater is purer and safer than surface water due to the protective qualities of the soil cover (Mishra et al., 2005).

Hydro chemical evaluation of groundwater systems is usually based on the availability of a large amount of information concerning groundwater chemistry. The increasing exploitation due to farming frequently causes deterioration in water quality. Therefore, variations in natural and human activities reflect spatial

variations in the hydro chemical parameters of the groundwater. The importance of water quality in human health has also recently attracted a great deal of interest (Pazand et al. 2011).

This work aims at studying the hydro-geologic setting of the area and the hydro-chemical nature of water from 15 randomly sampled ground water during Post-Monsoon Season in Tirupur district. Due to industrialization, pollutants, solid waste dumping near the factories, the ground water is highly contaminated. The objective of the study is to determine the geologic layers constituting the aquifer, its viability as source of potable/drinking water and also to compare the hydro-chemical and bacteriological properties of sampled bore wells with the Indian standard for drinking water quality (ISDWQ).

2 Materials and methods

2.1 Study area

Tirupur is located at 11.1075°N 77.3398°E on the banks of the Noyyal River. It has an average elevation of 295 metres (967 feet) and covers an area of 159.6 km^2 (61.6 sq m). It constitutes hills such as Anamalai, Sirumuga malai, Nilgiri hill (western ghats), Boluvampatti, Janakal and Vellingiri. River which drains this district include Noyyal, Bhavani, Amaravathi, Aliyar and Palar.

The Noyil River has its origin in the Boluvampatti valley of the Vellingiri hills and comes to be called the Swami Mudiyar. Further south it is joined by the Periyar and Chinnar.

The Amaravathi River rises in the Anjanad valley in the Kerala state between the Anamalai hills and the plains and flows in the north-eastern direction. Amaravathi dam is located on this river.

The Palar, Aliyar and Upar which are the main steams of the river Ponnani are originating from the Anaimalai hills and flows in a north-northwest direction on the southern part of the district, the Aliyar and Thirumoorthy dams are located on Aliyar and Palar respectively.

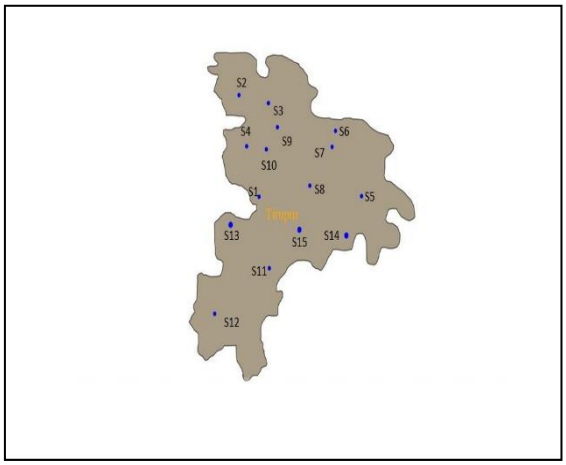

Fig 1. Location Map of the Study Area Showing Sampling Points

In this study a total of 15 samples were collected randomly in Tirupur zone during November and analysed for the water quality parameters such as Electrical conductivity, pH, Total hardness, Ca, Mg, Cl, Cr, Fe, No_3^-, So_4, Total dissolved solids and Total suspended solids by using standard procedure. The samples were collected in one litre high density polyethylene (HDPE) bottle pre-washed with dilute hydrochloric acid and rinsed two or three times with the sample. The samples were stored at 4 degrees prior to analysis in the laboratory. The location for which the samples are collected is shown in Fig 1.

2.2 Climate and Rainfall

The Climate in Tirupur is tropical with the mean maximum and minimum temperatures varying between 35 to 22 °C (95 to 72 °F). The summer occurs during the months March, April and May when the weather is hot and dry. The maximum temperature during the summer months will be around 35 °C (95 °F) and the minimum temperature will be around 29 °C (84 °F). The monsoon months are the months of June, July and August. These months are mainly characterized by mild showers and a reduced temperature. The post monsoon or winter months are September, October, November, December and January. These months generally have a cool climate and temperatures rarely rise beyond a maximum of around 29 °C (84 °F). The minimum temperature during this season will be around 24 °C (75 °F).

Due to the presence of the Palghat gap, the city receives rainfall from the South-west monsoon in the months from June to August. After a humid September, the North-east monsoon brings rains starts from October which lasts till early November. The average annual rainfall is around 700 mm (28 in) with the North East and the South West monsoons contributing to 47% and 28% respectively to the total rainfall.

2.3 Soil and Vegetation

The region is covered by red soil (50%), black soil (46.4%), other soil (3.6%). Medium to deep red calcareous soils is found mainly in Pollachi and Udumalpet taluks. Parts of Palladam, Avinashi and Udumalpet taluks are occupied by red non-calcareous soils. The highlands in Palladam and Avinashi taluks are mostly occupied by the black soils, which are dark grey to greyish brown in colour. The Alluvial soils are found in small patches along the Noyil River mainly in the upper reaches. The black soil is suitable for cotton cultivation. Tirupur is the major producer of maize, sorghum, paddy, groundnut, sugarcane. Ordinary well is major source of irrigation compared to cannel irrigation. The water table is available at the depth of 7m to 25m.

3 Result and Discussion

3.1 pH

The pH value of water indicates the logarithm of reciprocal of hydrogen ion concentration present in water. It is thus an indication of the acidity or the alkalinity of the water. Since the pH is the log reciprocal of H^+, the higher value of pH means lower hydrogen ion concentration, and thus represent the alkaline solution; whereas the lower value of pH means higher hydrogen ion concentration representing acidic solution. Truly speaking pure water is the balance combination of positively charged hydrogen ion (H^+) and negatively charged hydroxyl ion (OH^-). Hence if the pH of the water is more than 7, it will be alkaline and if it is less than 7, it will be acidic.

For the public supply pH must be kept close to 7 as possible. The lower value may cause tuberculation and corrosion, while the higher value may produce incrustation, sediment deposit, difficulties in chlorination, certain physiological effect on human system. Here the pH value dwells between 6.9 to 8.

Table 1: Results of analysed hydro chemical parameters from collected water samples

SAMPLE	TEMPRATURE °C	pH	Ec ms	TDS mg/l	TSS mg/l	TH mg/l	Ca mg/l	Mg mg/l	Fe mg/l	Cr mg/l	Cl mg/l	No3- mg/l	So4 mg/l
S1	29.50	7.80	1.30	200.00	110.00	600.00	112.22	487.78	0.09	0.00	89.97	45.00	40.00
S2	26.00	6.90	1.11	190.00	38.00	780.00	617.32	162.32	0.03	0.05	617.69	55.45	53.33
S3	28.90	7.10	1.58	140.00	40.00	1000.00	179.35	820.65	0.09	0.00	119.96	84.00	35.00
S4	27.30	7.00	0.70	140.00	130.00	350.00	63.12	286.88	0.18	0.00	66.66	21.00	29.00
S5	27.40	8.00	1.00	300.00	110.00	1750.00	354.69	1395.31	0.00	0.00	547.33	36.00	63.00
S6	27.20	7.90	1.00	220.00	80.00	1125.00	125.24	999.76	0.00	0.00	334.89	66.00	35.00
S7	26.00	7.00	1.21	140.00	35.00	1003.81	131.32	872.50	0.33	0.00	414.87	22.00	24.00
S8	26.00	7.20	1.35	300.00	140.00	647.50	109.21	588.29	0.00	0.05	303.65	15.60	66.00
S9	26.00	7.40	0.55	1350.00	40.00	1050.00	220.43	829.52	0.00	0.05	594.80	27.30	56.00
S10	32.80	7.10	1.30	950.00	400.00	735.00	170.33	310.00	0.00	0.08	119.00	16.40	1158.65
S11	31.10	7.70	1.60	1250.00	340.00	725.00	152.30	345.00	0.67	0.00	137.45	27.00	1225.00
S12	31.90	7.60	1.50	550.00	1910.00	240.00	200.40	39.60	0.00	0.08	240.00	60.00	2100.00
S13	28.00	7.00	1.58	800.00	360.00	253.30	150.29	103.01	0.00	0.13	163.99	81.00	62.00
S14	32.40	7.20	1.00	1650.00	220.00	400.00	143.28	177.57	0.00	0.10	222.43	80.00	423.00
S15	26.00	7.30	1.61	1800.00	90.00	850.00	194.37	655.63	0.11	0.05	470.10	31.00	26.00

3.2 Electrical conductivity

Electrical conductivity of water is a measure of water's ability to conduct electricity. Pure water is the poor conductor of electricity; but it shows significant conductivity when ion of dissolved salts is present in it.

Electrical conductance is the approximate measure of number of ions present in the water; and hence approximately measure the total dissolved solids in the water.

The element whose ion forms contribute to this measure include Calcium ($Ca^{+\ +}$), Magnesium ($Mg^{+\ +}$), Potassium (K^{+}), Bicarbonate (HCO_3^{-}), Sulphate ($SO_4^{-\ -}$) and Chloride (Cl^{-}), etc. The higher in the concentration of such ionic (dissolved) constituents, the higher will be the conductivity. In this sample the EC value varies between 0.5 - 1.7 ms.

3.3 Temperature

Temperature is not used to evaluate directly either portable water or wastewater. It is however, one of the most important parameters in natural surface water system. The temperature of surface water governs to a large extent the biological species present and the rate of activity. Temperature has an adverse effect on most chemical reaction that occur in natural water system. It also has a pronounced effect on the solubility of gases in water.

3.4 Total suspended solids

Suspended impurities are dispersion of solid particles, which can be removed by filtration or settling. They are two type - organic and inorganic. Clay, silica, oxides of iron magnesium are the inorganic type of suspended impurities. Wood pieces, disintegrated particles of dead animals, leaves, fishes, bacteria,

algae, protozoa, etc... are of organic origin. The suspended impurities impart turbidity and colour to the water. The variation of total suspended solids in the study area lies between 35- 1910 mg/l.

3.5 Total dissolved solids

The materials remained in water after filtration for the suspended solids analysis is considered to be dissolved. Total dissolved solids indicate the presence of minerals such as calcium, magnesium, sodium in various salt form and some organic matter. Many dissolved solids are undesirable in water. Dissolved minerals, gases and organic constituent may produce aesthetically displeasing colour, taste and odour. Some chemicals may be toxic, some of the dissolved organic matters have been shown to be carcinogenic. In this study area total dissolved solids varies from 140-1800 mg/l.

Permissible value of TDS as per Indian standard drinking water specification (IS 10500) is 500-2000mg/l. Table 2 shows the water quality characteristics based on TDS given by (Davis and Dewiest 1966)

Table 2: Davis and Dewiest water quality classification and % for given sample

TDS	Water Quality	Percentage of sample
<500	Desirable for drinking	53.33
500-1000	Permissible for drinking	20
<3000	Useful for drinking	26.6
>3000	Unfit for drinking and irrigation	0

3.6 Total hardness

Hardness is defined as the concentration of multivalent metallic cations in solution. At supersaturated conditions, the hardness cations will react with anions in water to form a solid precipitate. Hardness of water is due to the presence of soluble salts of calcium, magnesium and other heavier metals in water.

Water can be classified into four categories by Sawyer and McCarthy (1967): soft (<75 mg/L), moderately hard (75–150 mg/L), hard (150–300 mg/L), and very hard (>300 mg/L) based on the total hardness. These results are given in table. In this study area total hardness varies from 240 mg/l to 1750mg/l.

Table 3 show the categorization of ground water based on Total hardness according to Sawyer and Mc Carty's.

Table 3: Sawyer and Mc Carty's classification of ground water type and % of Sample

Total hardness	Water type	% Of sample
<75	Soft	0
75-150	Moderately Hard	0
150-300	Hard	13.33
>300	Very Hard	86.66

3.6.1 Non carbonate hardness

Non carbonate hardness is also called as permanent hardness. It is caused due to sulphites, chloride nitrates of calcium and magnesium. Calcium and magnesium are the most abundant elements in groundwater, which import greater soap consumption, scale formation in boilers and incrustation of pipe

lines. It is expressed in terms of $CaCO_3$ scale. In this study area calcium varies from 63.12mg/l to 354.69mg/l and magnesium varies from 103mg/l to 1395 mg/l.

In most waters calcium and magnesium maintains a state of equilibrium. A ratio namely index of magnesium hazard was developed by Paliwal (1972). According to this, high magnesium hazard value (>50 %) has an adverse effect on the crop yield as the soil becomes more alkaline. In the study area 80% of the sample has the magnesium hazard value (<50%)

Magnesium ratio = $Mg^{2+} \times 100/(Ca^{2+} + Mg^{2+})$

3.7 Chloride

Chloride is one of the major anions to be found in water from various sources such as weathering, intrusions of salt water, leaching of sedimentary rocks and soils, windblown salt in precipitation, domestic and industrial wastes, and municipal effluents (Karanth 1987; Hem 1985). The highest concentration of Cl- in water is usually taken as an index of pollution and considered as the origin of groundwater contamination (Loizidou and Kapetanios 1993). The maximum desirable limit of Cl as per Indian standard drinking water specification (IS 10500) is 250mg/l. In the given sample chloride concentration varies from 66mg/l to 617mg/l.

3.8 Nitrate

Nitrogen is originally fixed from the atmosphere and then mineralized by soil bacteria into ammonium. Nitrogen may present in the water in the form of free ammonia, albuminoid nitrogen, nitrites, nitrates. Nitrates indicate the presence of fully decomposed organic matter in the water. (NO_3) concentration varies from 21 to 84 mg/l with an average value of 44.5 mg/l. The NO_3 ions concentrations of the groundwater samples are within the desirable limit of 45 mg/l as per, in some regions it is deviated. The high concentration of NO_3 in drinking water is toxic and cause blue baby disease/methemoglobinemia in children and also gastric cancer and adversely effects [NS and cardiovascular system (CPCB 2008)]. Excessive concentration of nitrogen of any kind indicate pollution, and the form in which they present indicate the period of pollution.

3.9 Sulphate

Sulphate is found in most fresh water supplies. Some regions have higher sulphate levels than others. In foods, sulphate is present as the salts of sodium, calcium, iron, magnesium, manganese, zinc, copper, ammonium, and potassium. Sulphates can be naturally occurring or the result of municipal or industrial discharges. The sulphate concentration varies from 25 to 1225mg/l. As per Indian standard drinking water specification (IS 15000) it should be within 200 mg/l. Beyond the limit causes gastro intestinal irritation when magnesium or sodium is present.

3.10 Chromium

Natural chromium is rare Cr (VI) is the toxic form to humans. Cr (III) is slowly oxidised to Cr (VI) in water, toxic to plants. Varying tolerance to Cr salts in aquatic life. The maximum desirable limit as per Indian standard drinking water specification (IS 10500) is 0.05mg/l, above this limit may be carcinogenic. But here the Chromium concentration varies from 0 to 0.125mg/l through this the pollution of ground water is suspected due to the intrusion of industrial waste.

3.11 Iron

Significant quantities of iron will usually be found only in systematic devoid of oxygen such as ground waters or perhaps the bottom layers of stratified lakes. As per Indian standard drinking water specification (IS 10500) desirable limit of Fe is 0.3mg/l. Beyond this limit may affect the taste and appearance, has adverse effect on domestic users and water supply structure, promotes iron bacteria. The Iron concentration of the study area varies from 0 to 0.667mg/l.

Table 4: Standard Values and % of Sample Within and Exceeding Limit

Parameter	Desirable limit	Permissible limit	% Of sample within the permissible limit	% Of sample exceeding the permissible limit
PH	6.5	8.5	100	0
Total dissolved solids	500	2000	100	0
Total hardness	300	600	33.34	66.66
Calcium	75	200	73.74	26.66
Magnesium	30	100	6.67	93.33
Chloride	250	1000	100	0
Nitrate	45	100	100	0
Sulphate	200	400	73.34	26.66
Chromium	0.05	0.05	73.34	26.66
Iron	0.3	1	100	0

4 Statistical Analysis

4.1 Correlation

Correlation is a statistical measure that indicates the extent to which two or more variables fluctuate together. A positive correlation indicates the extent to which those variables increase or decrease in parallel; a negative correlation indicates the extent to which one variable increases as the other decreases. Correlation is a statistical measure (expressed as a number) that describes the size and direction of a relationship between two or more variables. A correlation between variables, however, does not automatically mean that the change in one variable is the cause of the change in the values of the other variable. The correlation is one of the most common and most useful statistics. A correlation is a single number that describes the degree of relationship between two variables.

A correlation matrix of twelve parameters namely, pH, Electrical Conductivity, Total Hardness, Dissolved Solids, Calcium, Magnesium, Chloride, Sulphite, Chromium, Iron, Nitrate among themselves was constructed as shown in Table 5. For the given water sample, it clearly shows that the correlation between Magnesium Hardness and Total Hardness is 0.936 (i.e..,) positively correlated to each other and $R < 1$. If the concentration of Magnesium Hardness increases then there is an increase in Total Hardness or Vice-Versa.

Table 5: Correlation Matrix of water quality parameters

	pH	EC	TDS	TSS	TH	Ca	Mg	Fe	Cr	Cl	No3-	So 4

pH	1											
EC	-0.230	1										
TDS	-0.063	0.064	1									
TSS	0.150	0.031	0.246	1								
TH	0.084	-0.286	-0.167	-0.358	1							
Ca	-0.206	-0.149	-0.023	0.077	0.287	1						
Mg	0.166	-0.269	-0.223	-0.405	0.936	-0.005	1					
Fe	0.031	0.101	-0.036	-0.091	-0.030	-0.054	-0.068	1				
Cr	-0.258	-0.023	0.243	0.134	-0.212	0.094	-0.290	0.159	1			
Cl	0.015	-0.298	0.129	0.069	0.512	0.635	0.384	-0.056	0.068	1		
No3-	0.014	0.101	-0.121	0.273	-0.110	0.105	-0.135	0.047	0.324	0.046	1	
So4	0.135	0.216	0.076	0.299	-0.302	-0.032	-0.365	0.671	0.432	-0.172	0.117	1

5. Conclusion

This study investigated the hydro chemical properties of the groundwater, to understand how much the groundwater is contaminated with chemicals and it is correlated. Thus, for different samples, parameters are done for finding the water quality and the ranges of all the samples are shown. The values of some parameter ranges are within permissible limits. Few Samples contain high chromium contents and thus it is not suitable for drinking purpose since it causes diseases. Based on the result of this study, Sample 10,11,12 is mostly contaminated when compared with other samples and the water is not suitable for drinking purposes, it is mainly due to the textile waste outlet which contaminates the groundwater. Hardness is relatively high due to the presence of bicarbonates, sulphates, and chlorides of calcium and magnesium present in the given samples. Hence Safety measures should be taken before it is used for either drinking purposes or Irrigational uses.

Reference

1. APHA (2005) Standard methods for the examination of water and wastewater, 21st edn. American Public Health Association, Washington DC.
2. Arveti N, Sarma MRS, Aitkenhead-Peterson JA, Sunil K (2011) Fluoride incidence in groundwater: a case study from Talupula, Andhra Pradesh, India. Environ Monit Assess 172:427–443.
3. Awadh SM, Ahmed RM (2013) Hydrochemistry and pollution probability of selected sites along the Euphrates River, Western Iraq. Arab J Geosci 6:2501–2518.

4. BIS (2003) Indian standards specification for drinking water 15:10500. Bureau of Indian Standards, New Delhi.
5. Bozdag A, Gocmez G (2013) Evaluation of groundwater quality in the Cihanbeyli basin, Konya, Central Anatolia, Turkey. Environ Earth Sci 69:921–937.
6. CGWB (2008) District groundwater brochure Karur district, Tamil Nādu. Central Ground Water Board, Chennai.
7. Davis SN, De Wiest RJM (1966) Hydrogeology, vol 463. Wiley, New York.
8. Dixon W, Chiswell B (1992) The use of hydro chemical sections to identify recharge areas and saline intrusions in alluvial aquifers, southeast Queensland, Australia. J Hydrol 130:299–338.
9. Doneen LD (1964) Notes on water quality in Agriculture Published as a Water Science and Engineering Paper 4001. Department of Water Science and Engineering, University of California.
10. Eaton FM (1950) Significance of carbonate irrigation water. Soils Sci 69:123–133.
11. Elango L, Kannan R, Kumar Senthil (2003) Major ion chemistry and identification of hydrogeochemical process of groundwater in a part of Kancheepuram District, Tamilnadu, India. J Environ Geosci 10:157–166.
12. Elkrail A, Kheir O, Shu L, Zhenchun H (2004) Hydrogeology of the northern Gezira area, Central Sudan. J Spat Hydrol 4:1–11.
13. Frengstad B, Banks D, Siewers U (2001) The chemistry of Norwegian groundwaters: IV. The pH-dependence of element concentrations in crystalline bedrock groundwaters. Sci Total Environ 277:101–117.
14. Hoek WVD, Konradsen F, Ensink JHJ, Mudasser M, Jensen PK. 2001. Irrigation water as a source of drinking water: is safe use possible? Trop Med Int Health. 6:46–54.
15. Karanth KR (1989) Quality of ground water. In: Karanth KR (ed) Ground water assessment development and management. Tata McGraw Hill, New Delhi, pp 217–275.
16. Loizidou M, Kapetanios EG (1993) Effect of leachate from landfills on underground water quality. Sci Total Environ 128:69–81.
17. Mishra, P.C.; Behera, P.C.; Patel, R.K. Contamination of water due to major industries and open refuse dumping in the steel city of Orissa–a case study. J. Environ. Sci. Eng. 2005, 47, 141–154.
18. Narayanan, C. Viswanatha, Dileep Kumarb, P.G and Ammadb, K.K. (2015) 'Statistical Analysis of Quality of Water in Various Water Shed for Kozhikode City, Kerala, India', Aquatic Procedia, Vol.4, pp.1078 – 1085.
19. Nickson RT, McArthur JM, Shresthn B, Kyaw- Nyint TO, Lowry D (2005) Arsenic and other drinking water quality issues, Muzaffargarh District, Pakistan. Appl Geochem 20(1):55–66.
20. Paliwal KV (1967) Effect of gypsum application on the quality if irrigation waters. Madras Agric J 59:646–647.
21. Pazand K, Hogarthian A, Ghanbari Y, Aghavali N (2011) Groundwater geochemistry in the Meshkinshahr Basin of Ardabil Province in Iran. Environ Earth Sci. 65:871–879.
22. Pazand K, Hezarkhani A, Ghanbari Singh K, Malik A, Mohan D, Sinha S (2004) Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River (India) -a case study. Water Res 38(18):3980–3992.
23. Singh AK, Mondal GC, Kumar S, Singh TB, Tewary BK, Sinha A (2008) Major ion chemistry, weathering processes and water quality assessment in upper catchment of Damodar River basin, India. Environ Geol 54:745–758.

24. Y, Aghavali N (2012) Geochemical and quality assessment of groundwater of Marand Basin, East Azarbaijan Province, northwestern Iran. Environ Earth Sci.
25. Sawyer GN, McCarthy DL (1967) Chemistry of sanitary engineers,
26. 2nd edn. McGraw Hill, New York, p 518.