



Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Assessment and correlation analysis of surface and ground water of Amaravathi river basin-Karur, Tamilnadu, India

Ahamed A Jafar* and Loganathan K

PG and Research Department of Chemistry, Jamal Mohamed College (Autonomous), Affiliated to Bharathidasan University, Tiruchirappalli – 620 020, Tamilnadu, India,

ABSTRACT

The present study has been made to evaluate the current status of physico-chemical contaminants and their sources in surface and groundwater of Amaravathi river basin. 33 water samples including 11 surface water samples and 22 groundwater samples were collected from different location of Amaravathi river basin during November 2011. The physico-chemical parameters such as pH, EC, TDS, TH, TA, NO₃, SO₄, PO₄, Na, K, Ca, Mg, Cl and F have been analyzed. The results were compared with water quality standard prescribed by ISI/ICMR/WHO and an attempt has been made to find whether the quality of groundwater suitable for drinking purposes or not. The correlation coefficients were calculated for water quality assessment.

Key words: Amaravathi River, Surface and Ground water, Karur, Water quality parameters, correlation matrix

INTRODUCTION

Water is a vital source of life which is extremely essential for survival of all living organisms. With rapid growing population and improved living standards the pressure on water resources is increasing. The rapid growth of urban areas has further affected the groundwater quality due to our exploitation of resources and improper waste disposal practices. Groundwater serves as a major source for drinking, irrigation and industry. Ground water is highly valued because of certain properties not posed by surface water [1]. Water gets polluted due to contamination by foreign matter such as microorganism, chemicals, industrial or other wastes or sewage.

The quality of surface waters is a very sensitive issue. Anthropogenic influences as well as nature process degrade surface waters and impair their use for drinking, industries, agriculture, recreation or other purposes [2, 3].

Amaravathi River, a major river in the state receives the effluents from textile industries, adding to the pollution load already present in the environment. As large textile industries are situated in Karur district, the groundwater gets contaminated at higher rate.

Study Area

Karur was built on the banks of River Amaravathi about 371 km southwest of Chennai, the capital of Tamilnadu. The district has a rich and varied cultural heritage. It was ruled by Cheras, Gangar, Cholas and the Vijayanagara Nayaks for short periods. The area is famous worldwide for its hand-loam textile products. TNPL, Chettinad cement factory, EID parry sugar factory, Bus body building industries are some of the important factories of Karur. It is located at 10°57' N 78°4' E has an average elevation of 122 metres (400 feet). It is spread over an area of 2,895.57 sq.km. with a population of 1, 76,588. Amaravathi River originates from Thirumurthimalai in Udumalpet taluk of Coimbatore district, Tamilnadu state. The direction of river flow is from south west to north east and the total length of river is 160 km. The Amaravathi enters into Karur district near Aravakurichi (30 km upstream of

Karur) and merge with Cauvery near Kattali village. The Amaravathi river water is severely polluted due to the discharge of the textile bleaching and dyeing units located in and around Karur town.



Figure 1: Study area of Amaravathi River Basin

Table 1: Details of sampling locations

Sampling Sites	Sampling Stations	Surface water samples code	Groundwater samples code	
			TLRB	TRRB
1	Nenjaikalipalayam	S ₁	A	a
2	Parvathinagar	S ₂	B	b
3	Kothappalayam	S ₃	C	c
4	Vaduvanampalli	S ₄	D	d
5	Kodiyur	S ₅	E	e
6	Chettipalayam	S ₆	F	f
7	Sukaliyur	S ₇	G	g
8	Sellandipalayam	S ₈	H	h
9	Thirumanilayur	S ₉	I	i
10	Melapalayam	S ₁₀	J	j
11	Natrajapuram	S ₁₁	K	k

TLRB – Towards Left side of the River Basin, *TRRB* – Towards Right side of the River Basin instrumental techniques. The procedures were followed from standard books and manuals [4-6].

The city gets most of its seasonal rainfall from the North-East monsoon from late September to mid-November. The average annual rainfall is about 855 mm. About 45% of land area is utilized for Agriculture. 4.76% of the land area

remains uncultivable land and 2.74% is forest area. The main crops are Paddy, Banana, Sugarcane and Groundnuts etc.

EXPERIMENTAL SECTION

Thirty three water samples were collected during November 2011 as monsoon season from eleven different sites, which are almost uniformly distributed over the river basin area. The details of the sampling sites are given in Table-1. Grap samples were collected in pre-cleaned 2L polythene bottles. The analysis was carried out systematically both volumetrically and by

RESULTS AND DISCUSSION

The various physico-chemical parameters of surface and groundwater sample values are presented in figures 2-15.

pH

pH is a measure of the intensity of acidity or alkalinity and the concentration of hydrogen ion in water. pH value below 4 produces sour taste and a higher value above 8.5 give alkaline taste [7]. The pH values varied between 7.44 to 8.46 and 6.92 to 7.84 (Fig. 2) for surface and groundwater samples respectively and were found within the limit prescribed by BIS and WHO [8].

Electrical Conductivity (EC)

Electrical Conductivity is a measure of water's capacity to conduct electric current. Generally, ground water tends to have high EC than surface water due to the presence of high amount of dissolved salts [9]. The EC in the study area varies between 806 to 1010 μScm^{-1} for surface water and 404 to 11800 μScm^{-1} for groundwater samples (Fig. 3). High values of EC may be due to running effluents, domestic and agricultural wastes containing high dissolved solids.

Total Dissolved Solids (TDS)

TDS indicates the general nature of water quality or salinity. The range of TDS for surface water falls in between 423 to 699 mg/L. Near Karur town, the river water is polluted due to the effluent discharge [10]. The TDS of groundwater ranges from 142 to 8720 mg/L (Fig. 4). The TDS concentration was found to be remarkably high at all the sites except sample c and a. The high value of TDS may be due to the various pollutants into groundwater. The high concentration of TDS decreases the palatability and may cause gastro-intestinal irritation in human [11, 12].

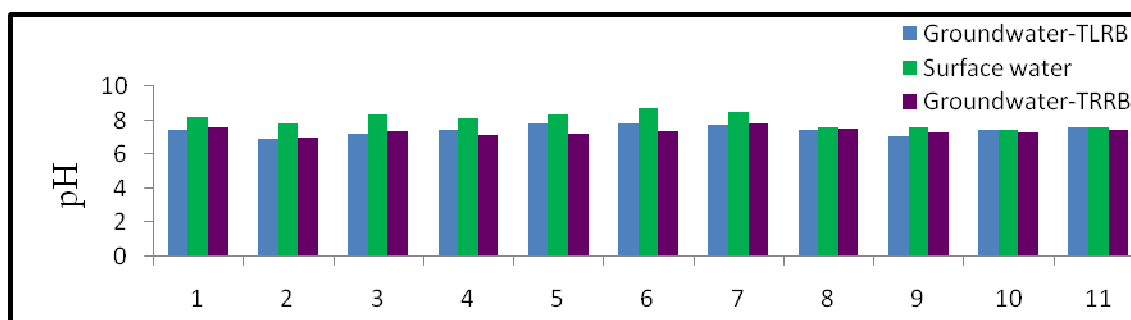


Figure 2: Concentration of pH in Surface and groundwater samples

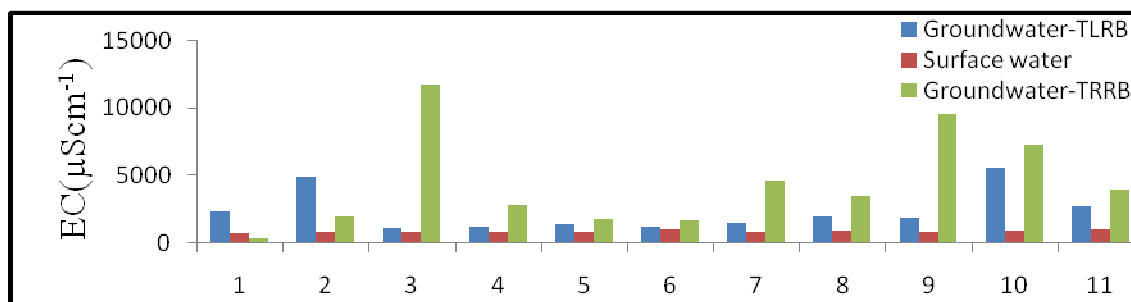


Figure 3: Concentration of EC in Surface and groundwater samples

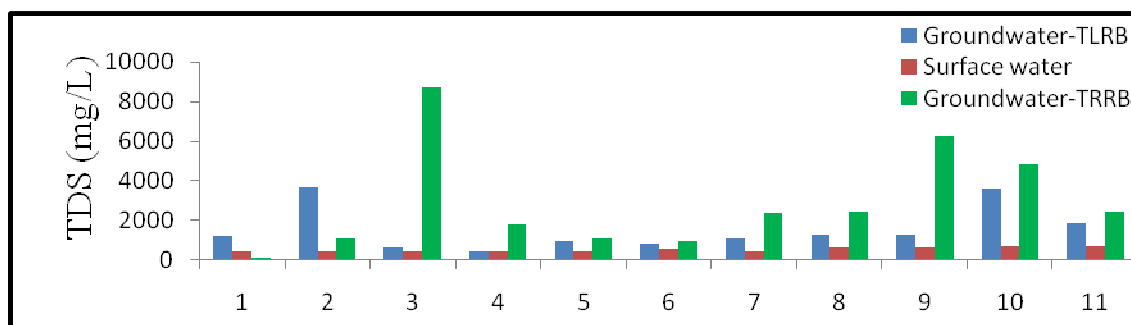


Figure 4: Concentration of TDS in Surface and groundwater samples

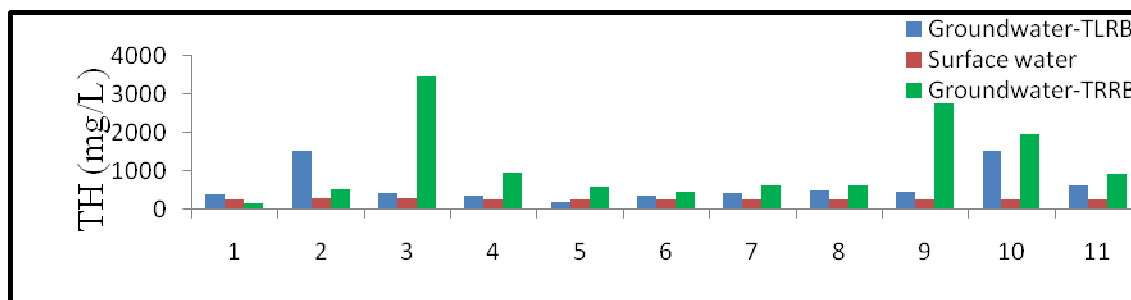


Figure 5: Concentration of TH in Surface and groundwater samples

Total Hardness (TH)

Hardness in water is caused by carbonates, fluorides and sulphates of calcium and magnesium. The principal hardness causing cations are calcium, magnesium, strontium, ferrous and manganese ions. The cations plus the most important anions that contributes are bicarbonates, sulphates, chlorides, nitrates and silicates. The TH in the study area varies between 148 to 3436 mg/L (Fig. 5) for ground water samples and all the surface water shows TH within the permissible limit of WHO and BIS. The hardness may be advantageous in certain conditions, if the corrosion in the pipes by forming a thin layer of scale and reduces the entry of heavy metals from the pipe to the water [13].

Total Alkalinity (TA)

The concentration of TA CaCO_3 in surface and ground water ranges from 154 to 221 mg/L and 82 to 575 mg/L (Fig. 6) respectively. The carbonate alkalinity is absent in all the stations. Therefore the total alkalinity is mostly due to the presence of bicarbonate. Alkalinity (150 mg/L) has been found conducive to productivity of water bodies [14]. The high alkalinity imparts water with unpleasant taste and may be deleterious to human health with high pH, TDS and TH.

Chloride (Cl)

Chloride occurs in all types of waters. An excess of Cl in water is usually taken as an index of pollution and considered as tracer for groundwater pollution. The concentration of Cl in the surface water samples ranged between 122 to 196 mg/L. The contribution of chloride in the groundwater is due to minerals like apatite, mica, and hornblende and also from the liquid inclusions and igneous rocks [15]. In groundwater samples the minimum and maximum recorded values of Cl were 80 to 3535 mg/L (Fig. 7). High Cl⁻ content of groundwater is likely to originate from pollution sources such as domestic effluents fertilities, and septic tanks. Increase in Cl⁻ level is injurious to people suffering from diseases of heart or kidney.

Fluoride (F)

Fluoride occurs in all natural water supplies. Fluoride in natural waters may originate from the solution of fluoride or apatite and more commonly from the solution of fluoride – bearing micas and amphiboles. Fluoride is common in semi-arid climate with crystalline igneous rocks and alkaline soils [16]. The fluoride concentrations in the surface water samples varied from 0.52 to 0.72 mg/L (Fig. 8) and were found within the limit prescribed by WHO. The fluoride concentration in groundwater is largely by presence of Ca, Mg, Na, SiO_2 , PO_4 , pH and alkalinity. The fluoride concentration in ground water varied from 0.3 to 3.9 mg/L. Ingestion of water with fluoride concentration above 1.5 mg/L causes fluorosis or crippling effects.

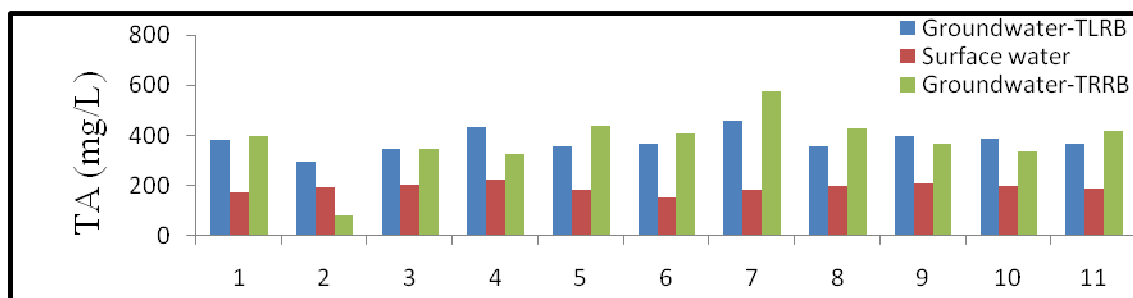


Figure 6: Concentration of TA in Surface and groundwater samples

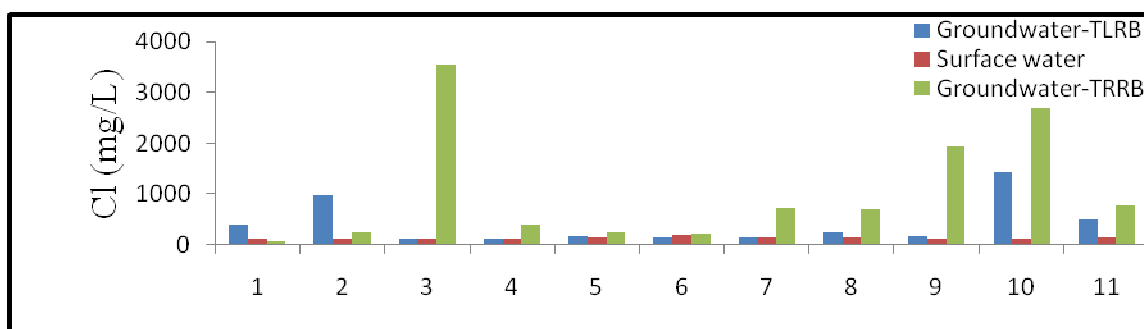


Figure 7: Concentration of Cl in Surface and groundwater samples

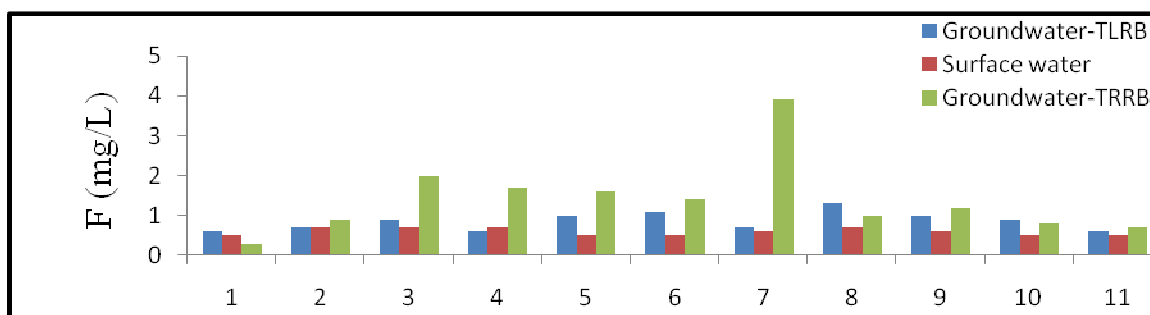
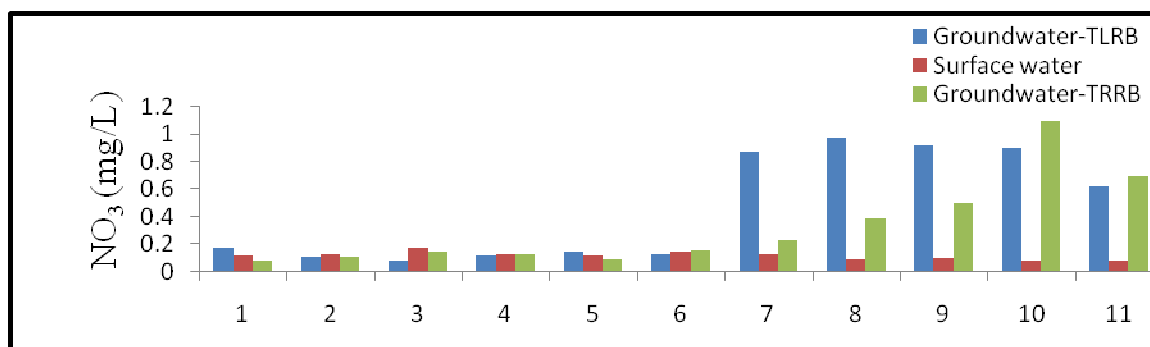


Figure 8: Concentration of F in Surface and groundwater samples

Figure 9: Concentration of NO₃ in Surface and groundwater samples

Nitrate (NO₃)

The Nitrate ion concentration in surface water varies from 0.08 to 0.18 mg/L. In groundwater, the nitrate content ranged from 0.08 to 1.10 mg/L (Fig. 9) which indicates that the groundwater has not been affected by nitrate. Human and animal wastes, application of fertilizers and chemicals, seepage and silage through drainage system are the main sources of nitrate contamination of groundwater [17]. Nitrate concentration above the recommended value of 10 mg/L is dangerous to pregnant women and poses a serious health threat to infants less than three to six months of age because of its ability to cause methaemoglobinaemia or blue baby syndrome in which blood loses its ability to carry sufficient oxygen [18].

Sulphate and Phosphate (SO₄ & PO₄)

A sulphate ion is one of the major anions occurring in natural waters. The sulphate content in surface water samples and groundwater samples were found within the acceptable limits of 200 mg/L (Fig. 10) prescribed by BIS 2003 and WHO 2005. Many sulphate components are readily soluble in water. Most of sulphate components originate from the oxidation of sulphite ores, presence of shales and the solution of gypsum and anhydrite. Under anaerobic conditions, sulphate ion is reduced to sulphide ion, which establishes equilibrium with hydrogen ion to form hydrogen sulphide. The presence of hydrogen sulphide leads to corrosion of pipes [19]. Phosphate an essential nutrient for living organisms occurs in water as both dissolved and particulate species.

Phosphate enters into groundwater from phosphate containing rock fertilizers and percolation of sewage and industrial wastes. Phosphate rock which is primarily tricalcium phosphate (Ca₃(PO₄)₂) and apatite, (CaF₂.3Ca₃(PO₄)₂) is sparingly soluble in water. A mixture of CaH₂(PO₄)₂ and gypsum, marked under the name of super phosphate of lime, is used as phosphate fertilizer [20]. PO₄ in the surface water and groundwater samples were well below the permissible limit and the concentration varied from 0.01 to 0.96 mg/L (Fig. 11).

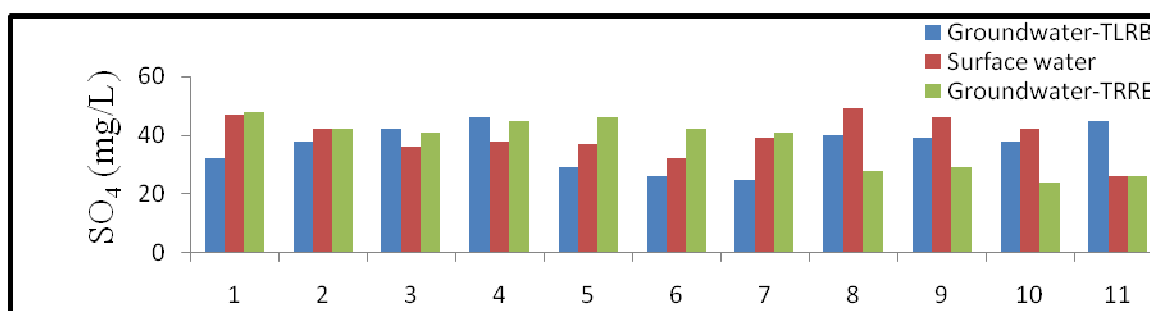


Figure 10: Concentration of SO₄ in Surface and groundwater samples

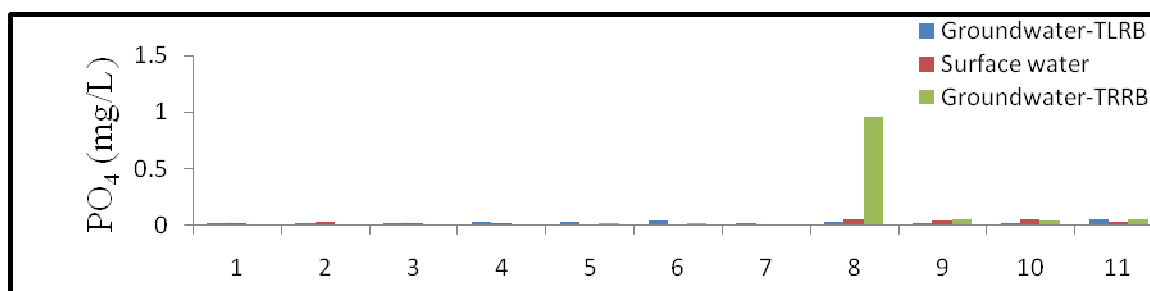


Figure 11: Concentration of PO₄ in Surface and groundwater samples

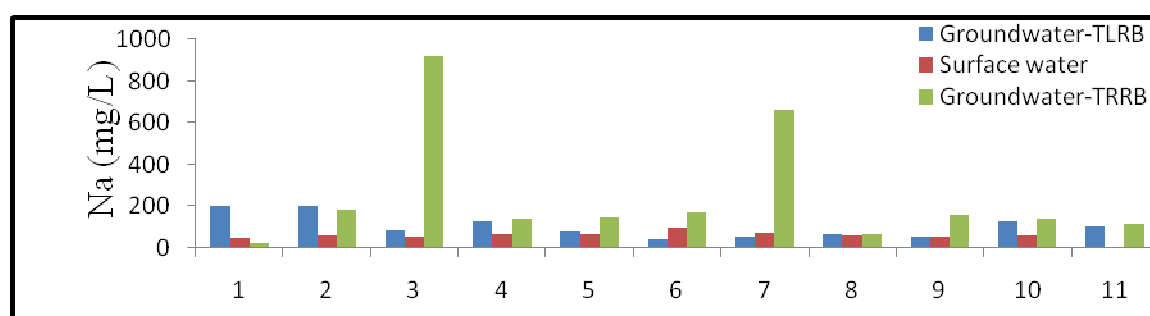


Figure 12: Concentration of Na in Surface and groundwater samples

Sodium and Potassium (Na & K)

Sodium and potassium are the most important minerals occurring naturally. Sodium plays an important role in human body. Regulatory action is exercised by sodium, potassium, calcium and magnesium. The Flux of these ions through cell membranes and other boundary layers send signals that turn metabolic reactions on and off. The maximum permissible limit of sodium in water is 200 mg/L. Sodium in surface water found to be within the limit and groundwater ranges from 25.25 to 662.5 mg/L (Fig. 12), except station B and g, all the other stations are all below the permissible limit.

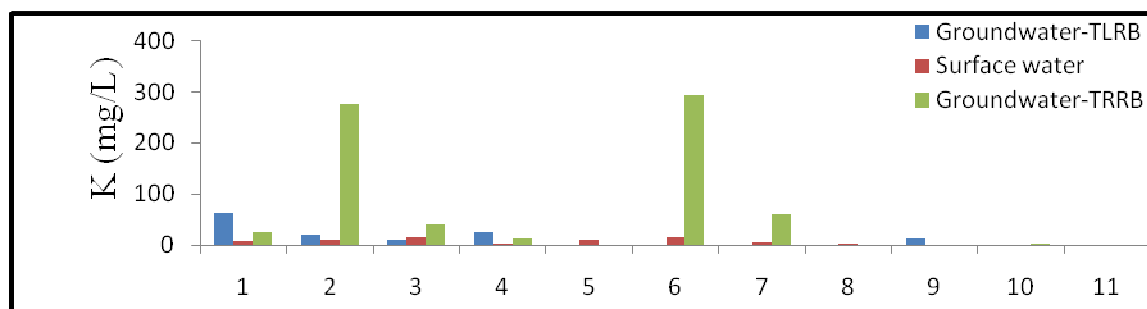


Figure 13: Concentration of K in Surface and groundwater samples

Sodium and potassium concentrations are influenced by the cation exchange mechanism. Potassium content in the study area was found in the range of 0 to 294.5 mg/L. Surface water lies within the safe range of WHO limit of 12 mg/L (Fig. 13). Excess amount of potassium present in water may lead nervous and digestive disorder [21].

Calcium and Magnesium (Ca & Mg)

Calcium and magnesium ions present in groundwater is particularly derived from leaching of lime stones dolomites, gypsum and anhydrites, whereas the calcium ion is also derived from cation exchange process [22]. Ca^{2+} in surface water ranged from 38 to 43 mg/L and found to be within the WHO limit (75 mg/L). Calcium is very essential for nervous system and for formation of bones and teeth. The concentration of calcium in groundwater ranges from 27 to 1154 mg/L (Fig. 14).

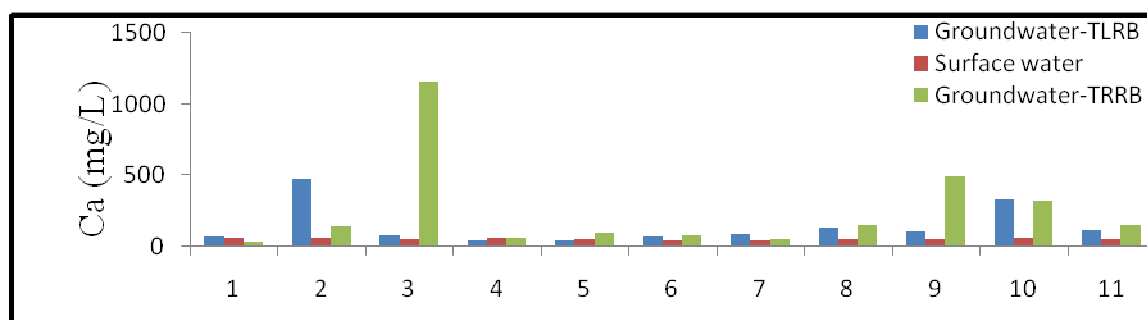


Figure 14: Concentration of Ca in Surface and groundwater samples

The samples exceeding the acceptable limits might be due to the geology of the area. The area is basically of granitic terrain. The higher concentration of calcium, magnesium, chlorides and bicarbonates in several cases are probably due to their low rate of removal by soil [23].

The excess of Ca^{2+} causes kidney or bladder stone and irritation in urinary passages. Magnesium is a beneficial metal, but it is toxic at high concentration. Mg^{2+} salts are cathartic and divertic may cause laxative effect, while deficiency may cause structural and functional changes. Mg ions in surface water varied from 25 to 35 mg/L. It is essential as an activator of many enzymes. The content of Mg^{2+} in groundwater ranges from 19 to 368 mg/L (Fig. 15). Mg^{2+} content are mostly due to weathering of magnesium minerals and leachy of dolomites.

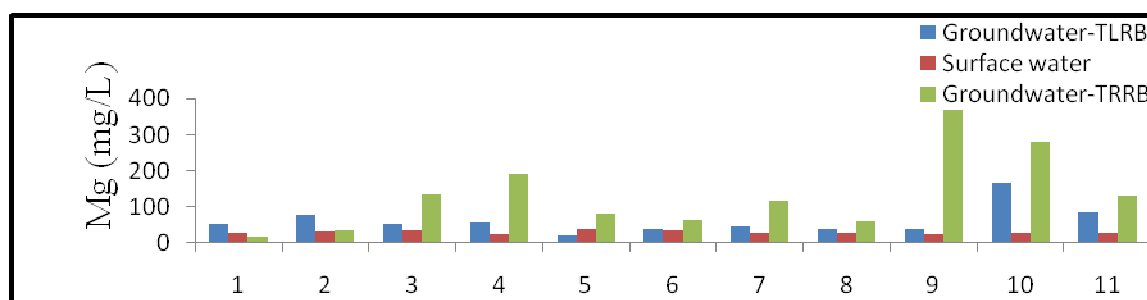
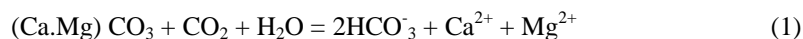


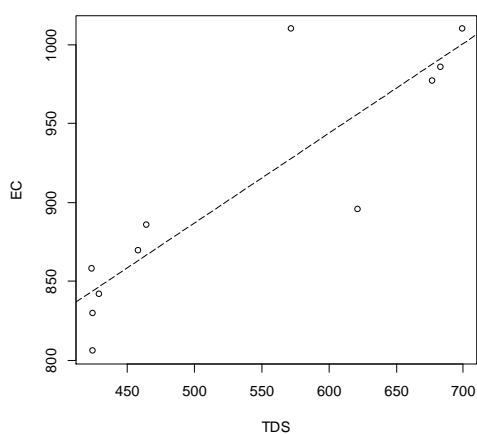
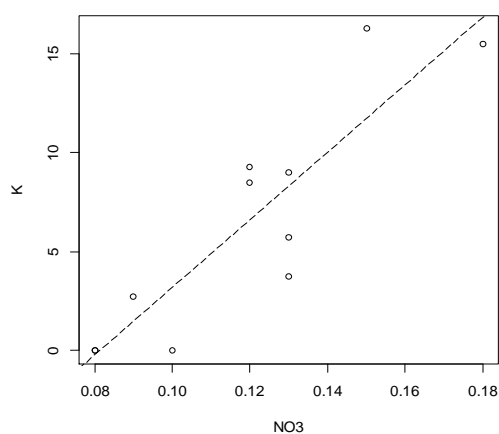
Figure 15: Concentration of Mg in Surface and groundwater samples

Correlation matrix and their relationships

Correlation analysis is a preliminary descriptive technique to estimate the degree of association among the variables involved. Correlation matrix between various parameters for surface and groundwater is shown in tables 2-4. Surface water samples parameters were found to bear statistically significant correlation with each other indicating close association of these parameters with each other. The high positively correlated values were found between EC versus TDS ($r=0.9$), pH versus K ($r=0.8$) and K versus NO_3^- ($r=0.9$) and negatively correlated with pH versus PO_4^{3-} ($r=-0.9$) and Ca versus Cl ($r=-0.8$) is shown in Fig. 16 (a,b,c,d)

Table 2: Correlation matrix for Amaravathi River water samples

Parameters	Temp	EC	TDS	pH	TA	TH	Ca	Mg	Na	K	Cl	F	SO_4^{2-}	PO_4^{3-}	NO_3^-
Temp	1.0	-0.6	-0.8	0.8	-0.3	0.4	-0.3	0.5	0.5	0.7	0.1	0.2	-0.2	-0.8	0.8
EC		1.0	0.9	-0.4	-0.3	-0.2	-0.3	-0.2	-0.1	-0.3	0.6	-0.3	-0.3	0.5	-0.5
TDS			1.0	-0.7	0.0	-0.4	-0.1	-0.4	-0.3	-0.6	0.3	-0.3	0.0	0.7	-0.7
pH				1.0	-0.5	0.1	-0.5	0.6	0.6	0.8	0.4	-0.1	-0.3	-0.9	0.8
TA					1.0	0.1	0.6	-0.4	-0.2	-0.5	-0.7	0.7	0.3	0.4	-0.1
TH						1.0	0.5	0.2	0.2	0.5	-0.3	0.5	0.1	0.0	0.5
Ca							1.0	-0.6	-0.2	-0.4	-0.8	0.3	0.5	0.5	-0.3
Mg								1.0	0.3	0.8	0.4	-0.1	-0.4	-0.5	0.6
Na									1.0	0.5	0.2	0.1	0.3	-0.3	0.5
K										1.0	0.3	0.1	-0.2	-0.7	0.9
Cl											1.0	-0.5	-0.6	-0.3	0.1
F												1.0	0.3	0.1	0.3
SO_4^{2-}													1.0	0.5	-0.2
PO_4^{3-}														1.0	-0.7
NO_3^-															1.0

R=0.9(+VE CORRELATION)**Fig 16a EC vs TDS****Fig 16b K vs NO₃**

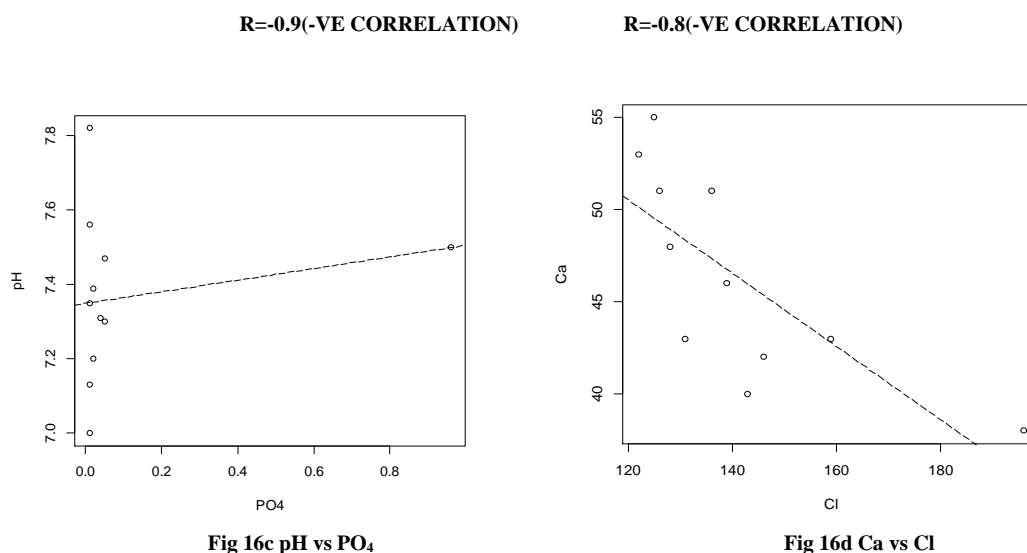


Figure 16: Correlation matrix relationships for Surface water samples

Groundwater samples towards left side of the river basin had a strong correlation with a number of parameters like EC versus Ca, TDS versus Ca, Cl versus TH and Cl versus Mg ($r=0.9$) and is shown in Fig. 17 (a,b,c,d), indicating the high mobility of their ions. Thus, the single parameter of TDS can give a reasonable good indication of a number of parameters [24].

Table 3: Correlation matrix for groundwater samples towards Left side of the River Basin

Parameters	Temp	EC	TDS	pH	TA	TH	Ca	Mg	Na	K	Cl	F	SO ₄ ²⁻	PO ₄ ³⁻	NO ₃ ⁻
Temp	1.0	-0.6	-0.8	0.8	-0.3	0.4	-0.3	0.5	0.5	0.7	0.1	0.2	-0.2	-0.8	0.8
EC		1.0	0.9	-0.4	-0.3	-0.2	-0.3	-0.2	-0.1	-0.3	0.6	-0.3	-0.3	0.5	-0.5
TDS			1.0	-0.7	0.0	-0.4	-0.1	-0.4	-0.3	-0.6	0.3	-0.3	0.0	0.7	-0.7
pH				1.0	-0.5	0.1	-0.5	0.6	0.6	0.8	0.4	-0.1	-0.3	-0.9	0.8
TA					1.0	0.1	0.6	-0.4	-0.2	-0.5	-0.7	0.7	0.3	0.4	-0.1
TH						1.0	0.5	0.2	0.2	0.5	-0.3	0.5	0.1	0.0	0.5
Ca							1.0	-0.6	-0.2	-0.4	-0.8	0.3	0.5	0.5	-0.3
Mg								1.0	0.3	0.8	0.4	-0.1	-0.4	-0.5	0.6
Na									1.0	0.5	0.2	0.1	0.3	-0.3	0.5
K										1.0	0.3	0.1	-0.2	-0.7	0.9
Cl											1.0	-0.5	-0.6	-0.3	0.1
F												1.0	0.3	0.1	0.3
SO ₄ ²⁻													1.0	0.5	-0.2
PO ₄ ³⁻														1.0	-0.7
NO ₃ ⁻															1.0

R=0.9(+VE CORRELATION)

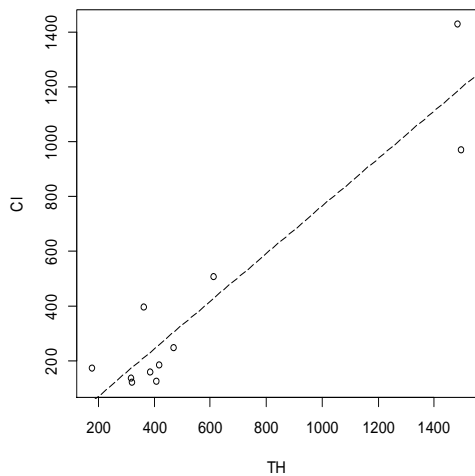


Fig 17a Cl vs TH

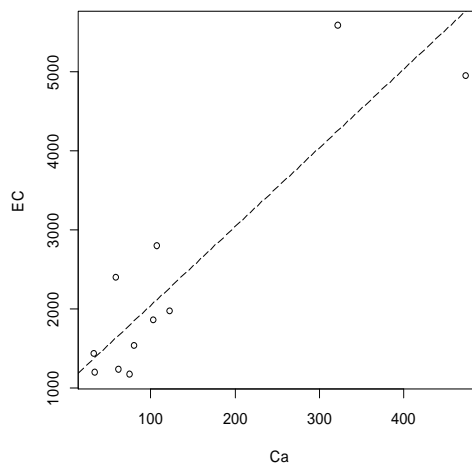


Fig 17b EC vs Ca

R=0.9(+VE CORRELATION)

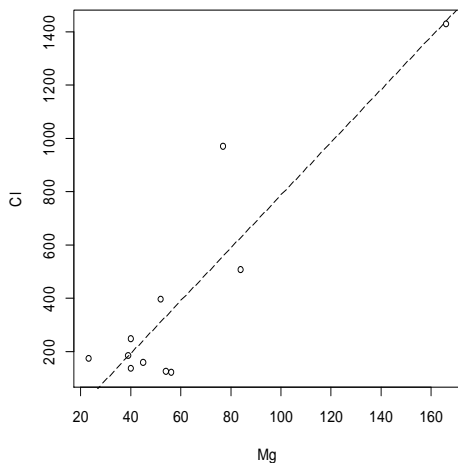


Fig 17c Cl vs Mg

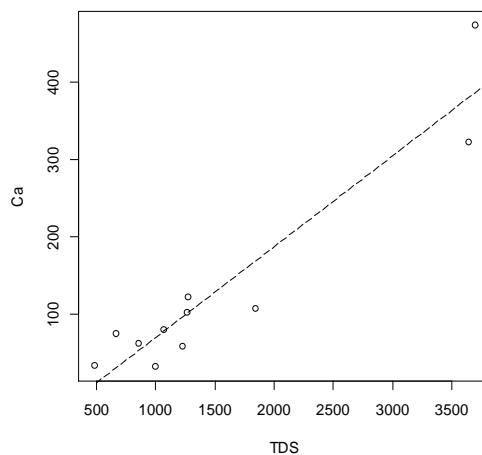


Fig 17d Ca vs TDS

Figure 17: Correlation matrix relationships for Groundwater samples towards Left side of the River Basin

R=0.9(+VE CORRELATION)

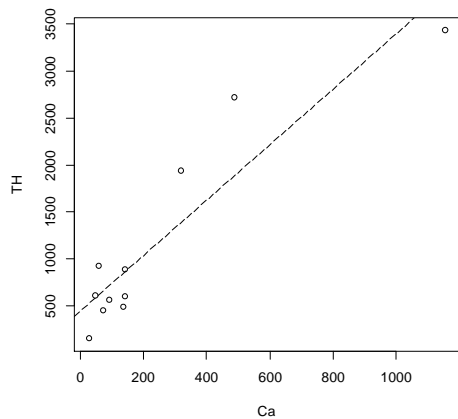


Fig 18a TH vs Ca

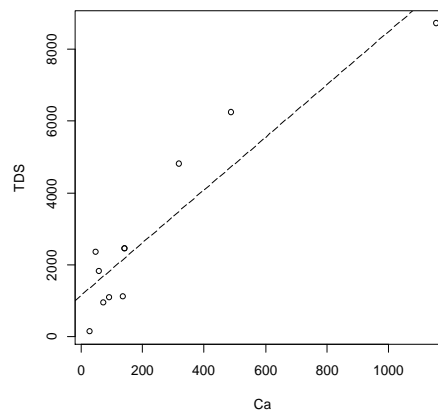


Fig 18b TDS vs Ca

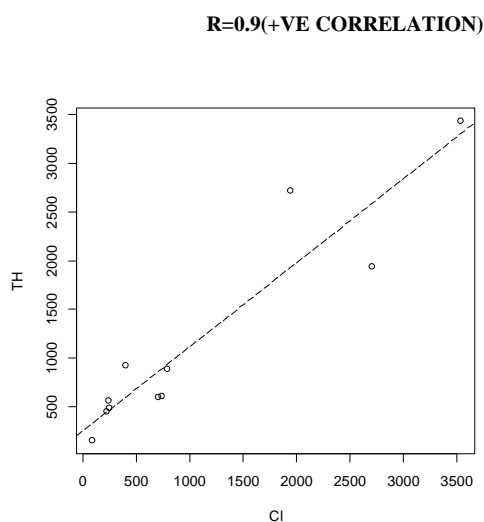


Fig 18c TH vs Cl

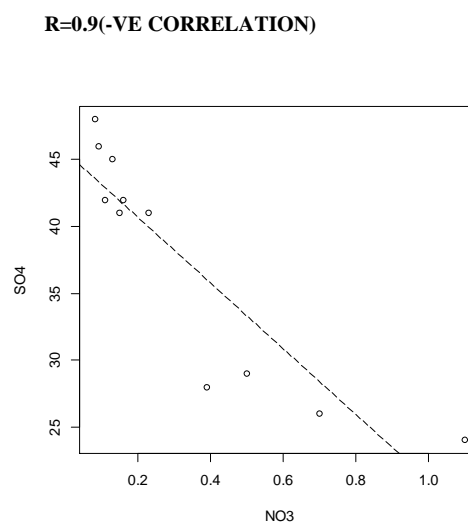
Fig 18d SO₄ vs NO₃

Figure 18: Correlation matrix relationships for Groundwater samples towards Right side of the River Basin

Table 4: Correlation matrix for groundwater water samples towards Right side of the River Basin

Parameters	Temp	EC	TDS	pH	TA	TH	Ca	Mg	Na	K	Cl	F	SO ₄ ²⁻	PO ₄ ³⁻	NO ₃ ⁻
Temp	1.0	-0.2	-0.2	0.0	0.1	-0.2	-0.1	-0.3	0.3	0.6	-0.2	0.5	0.4	-0.4	-0.3
EC		1.0	1.0	0.0	0.0	1.0	0.9	0.7	0.6	-0.3	0.9	0.2	-0.4	-0.1	0.4
TDS			1.0	0.0	0.0	1.0	0.9	0.6	0.6	-0.3	1.0	0.2	-0.4	0.0	0.3
pH				1.0	0.8	-0.1	-0.1	-0.1	0.3	-0.3	0.0	0.4	-0.1	0.2	0.1
TA					1.0	-0.1	-0.2	0.0	0.2	-0.5	-0.1	0.5	-0.1	0.2	0.1
TH						1.0	0.9	0.7	0.5	-0.3	0.9	0.1	-0.4	-0.2	0.3
Ca							1.0	0.4	0.7	-0.2	0.9	0.1	-0.2	-0.1	0.1
Mg								1.0	0.0	-0.4	0.6	0.0	-0.6	-0.2	0.6
Na									1.0	0.0	0.6	0.7	0.2	-0.2	-0.2
K										1.0	-0.3	0.0	0.3	-0.2	-0.4
Cl											1.0	0.1	-0.4	-0.1	0.5
F												1.0	0.3	-0.2	-0.3
SO ₄ ²⁻													1.0	-0.4	-0.9
PO ₄ ³⁻														1.0	0.1
NO ₃ ⁻															1.0

Groundwater samples on right side show some good correlation among TH versus Ca, TDS versus Ca, TH versus Cl and Ca versus Cl ($r=0.9$) and negative correlation with SO₄ versus NO₃ ($r=-0.9$) is shown in Fig. 18 (a,b,c,d). The above discussion implies that the groundwater has been extensively damaged and cause pollution in surface and groundwater.

CONCLUSION

In the present study, 33 water samples were analyzed, Most of the river water samples were found within the permissible limit except total alkalinity. The groundwater samples showed deviation from water quality standards indicating groundwater contamination. Maximum samples having excess of EC, TDS, TA, TH, Ca, Mg, Na, K, Cl and some samples having high amount of fluoride indicating poor water quality and water from these sites is unfit

for drinking purpose. Correlation determination provides quick monitoring of the quality of groundwater. Hence, proper care must be taken to avoid any contamination of groundwater and its quality be monitored periodically.

Acknowledgement

The authors are thankful to the Management Committee and the Principal of Jamal Mohamed College for providing necessary laboratory facilities.

REFERENCES

- [1] A Abdul Jameel; J Sirajudeen. *Environ. Monit. Assess.*, **2006**, 123, 299-312.
- [2] V Simenov; J A Stratis; C Samara. *Water Research*, **2003**, 37, 4119-4124.
- [3] S Ananthakrishnan; A Jafar Ahamed. *J. Chem. Pharm. Res.*, **2012**, 4 (1), 596-600.
- [4] APHA **2005**. Standard methods for the examinations of water and wastewater, 21st edition, American Public Health association, Washington.
- [5] BIS **2003**. Indian standards specification for drinking water IS: 10500, Bureau of Indian standards, New Delhi.
- [6] R K Trivedy; P K Goel; **1986**. Chemical and Biological methods for water pollution studies, Environmental publication, Karad.
- [7] V T Patil; P R Patil. *E-J. Chem.*, **2010**, 17 (1), 111-116.
- [8] WHO **2005**. International standards for drinking water, World Health Organization, Geneva.
- [9] K L Prakash; R K Somashekar. *J. Environ. Bio.*, **2006**, 27(4), 633-637.
- [10] R Rajamancikam; S Nagan. *Int. J. Environ. Sci.*, **2010**, 1, 91-108.
- [11] Suman Mor; Khaiwal Ravindra; R P Dahiya; A Chandra. *Environ. Monit. Assess.*, **2006**, 118, 435-456.
- [12] C J Rabinove; R H Long Ford; J W Brook Hart. *Geol. Sur. Water supply Paper*, **1958**, 16, 1-4.
- [13] V S Shrivastava; P R Patil. *Nat. Environ. Pollut. Tech.*, **2002**, 1(3), 279-283.
- [14] Deepti Mishra, ManisMudgal, Mohd Akramkhan, B Chakradhar. *J. Sci. Ind. Res.*, **2009**, 68, 964-966.
- [15] P K Das; S D Malik. *J. Indian. Water Res. Soc.*, **1988**, 8(3), 31-41.
- [16] P R Salve; A Maurya; P Kumbhare. *Bul. Environ. Contam. Toxicol.*, **2008**, 81, 289-293.
- [17] G D Agrawal; S K Lunkad; T Malkhed. *Water Sci. Tech.*, **1999**, 39(3), 67-75.
- [18] M R Burkart; D W Kolpin. *J. Environ. Qual.*, **1993**, 22, 646-656.
- [19] Sawyer; N Clair; L Perry; Gene F Perkin; **2000**. Chemistry for environmental engineering: 4th ed., Tata McGraw-Hill, New Delhi.
- [20] M K Gupta; Vibha sing; Poonam Raj Uanshi; Kavitha Raj; Sahab Dass. *Environ. Monit. Assess.*, **1999**, 59, 275-285.
- [21] G Raja; P Venkatesan. *E-J. Chem.*, **2010**, 7(2), 473-478.
- [22] S Krishnakumar; V Rammohan; J Dajkumarsahayan; M Jeevanandam. *Environ. Monit. Assess.*, **2009**, 159, 341-351.
- [23] R K Somashekar; V Rameshven; Chethanasuvarma. *J. Environ. Pollut.*, **2000**, 7(2), 101-109.
- [24] K Ravindra; Ameena; Meenakshi; Monika; Rani; A Kaushik *Environ. Monit. Assess.*, **2003**, 5, 419-426.