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Monthly Monitoring of Physicochemical and Radiation Properties of Kufa River, Iraq

Sadiq Kadhum Lafta Alzurfi, Ali Abid Abojassim* and Hussien Abid Ali Mraity
Faculty of Science, University of Kufa, Al-Najaf Box 21, Najaf, Iraq

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Abstract. Increasing anthropogenic activities can lead to a dramatic effect on the quality of the planet surface water such as river, lake and wetland among others (i.e. groundwater and atmospheric water). Water samples were collected from Kufa river during six months (i.e. started from November, 2015 to April, 2016). Six stations were selected alongside the river flow. The samples were analysed for physico-chemical and radiation properties (air temperature, water temperature, pH, total hardness, Ca^{+2}, Mg^{+2}, total dissolved solids, dissolved oxygen, biological oxygen demand, turbidity, total alkalinity, electrical conductivity and radon concentration). The resulted data of various physicochemical parameters indicate that in some water samples, the EC, total hardness, BOD, turbidity, and total dissolved solids were found to be high when compared with the limits of WHO standards. Regarding the radon concentration, the results reveal that the radon level of all studied areas were lower than those published in literature. Finally, the findings the river's water could be unsafe for drinking when the physicochemical analysis taken into account.

Keyword: physicochemical properties, radon concentrations, Kufa river

Introduction

Kufa river extends from Al-Kifl city via Al-Najaf governorate to Al- Diwaniyah city; the total length of this river is around 36 km long with an approximate flow rate of 552 m^3/ sec. The water level in this river undergoes large fluctuations. To illustrate, the highest level occurs during the high rainy season (end of March to early of April), whereas the lowest water level occurs in summer (MWR, 2007). Increasing urbanization of Kufa city had negative implications on water quality where the domestic effluents are directly disposed into the river without any consideration for the environmental consequences. Nevertheless, transported radioactive matters (e.g. radon gas) should also be considered as they may have their own impact too. Radon is a colourless, odourless and radioactive noble gas that is resulted from uranium decay series, which exists elsewhere on the earth. Furthermore, radon is an alpha particle emitter that decays into a chain of progenies of gamma and alpha emitters. This means that the radon atoms in the air can decay and produce other new atoms. The resulting atoms called radon progeny. These atoms can attach themselves to a tiny dust particle in an indoor air. As a result, the dust particles could easily be entered into the respiratory system and increase the chance of developing lung cancer over long period of time. In this context, certain types of radon based lung cancer have been recognized in literature especially those caused by smoking (BEIR, 1999). Overall, the US Environmental Protection Agency (USEPA, 1991) has identified pollutants relying on quality standards as follows:

- The concentration of chemical compounds and elements, i.e organic, chlorine, nitrates, ammonia, phosphorus, sulphates, and others.
- Pollutants that have an effect on the physical and chemical properties such as temperature, alkalinity conductivity, pH, DO, hardness and TDS.
- Biological contaminants include pathogenic bacteria, viruses, protozoa, helminthes, and phytoplankton.
- Radionuclides also includes natural radioactive families such as ^{238}U and ^{232}Th and their decay chain includes the production of radon-222; 220; 219 progenies. The latter are all emitting alpha particles. Some other radioactive elements emit beta and gamma rays.

It should be noted that the destination of industrial pollutants when entering the water surface either remain unchanged and immobile in primary station or move via transportation, volatilization, leaching, adsorption, and sedimentation processes. Finally, it might also move under the influence of gravity and diffusion where in some cases transmitted *via* biological and chemical

*Author for correspondence;
E-mail: ali.alhameedawi@uokufa.edu.iq

processes (e.g. aerobic and anaerobic decomposition) and bioaccumulation *via* some weathering processes (Weiner, 2000).

This study is aimed to monitor the physical, chemical and radiation properties of the six stations along side of the Kufa river's water using different techniques and comparing the findings with published standards for water. These stations were identified as sampling sites using a geographical positioning system (GPS)

Study area. Euphrates river in the Kifl city is divided into two branches namely, Abbasid and Kufa rivers. It runs from the Kifl city to the Diwaniyah city with a total length of about 36 kilometers and a flow rate of 375 [m^3/s], and an actual capacity of 552 [m^3/s]. The depth of water in this river changes and has a marked high level during the flooding seasons at the end of March to beginning of April and has a low water level in the summer's months (Al-Haidarey, 2009).

Many villages, farm lands and cities (e.g.Najaf and Kufa) lie alongside the river, where the waste of human and industrial fluid (industrial district area, Kufa cement plants and leather factory and others), together with rainy water and hospitals waste drain into the river directly without treatment.

The geographical positionging system (GPS) use in (Fig. 1) as follows:

- First station (St.1): Located north of Imam Ali Bridge about 1 km; this characterized by there was no industrial activity or human except agricultural activities.
- Second station (St.2): Located near Al-Barrakhia treatment plant for domestic wastes of the Kufa city.
- Third station (St. 3): located at 1 km away from the second station.
- Fourth station (St. 4): Located at 1.3 km away from the third station.
- Fifth station (St. 5): Located at 1.7 km away from the fourth station under the cement plant bridge.
- Sixth station (St. 6): Located 3 km away from the fifth station.

Materials and Methods

Samples of water were collected during day from the selected stations of Kufa river for the period starting from November, 2015 to April, 2016. Six stations were chosen for monitoring the physical, chemical and radiation properties of water in Kufa river. Analysis of the samples was achieved in the laboratory of Ecology Department/Faculty of Science/Kufa University. The samples were collected from a depth of 20 cm in each station (using polyethylene container). Air and water temperature was measured using mercury thermometer (0-100°C, UK), while the electrical conductivity, TDS, salinity, and pH were measured using multi meter (WTW, Germany). A modified method of Winkler (APHA,1995) was adapted to determine DO after fixing in field, the turbidity was measured using portable Turbid meter (Lovibond, Germany) after calibration of the meter using different solutions (0.01,10,1000). Total alkalinity was measured according to Lind (1979), whereas, total hardness, Ca^{+2} and magnesium hardness were measured according to APHA (1995). Radon concentration (Bq/m^3) was measured using RAD-7 detector. The RAD-7 is a radon-in-air monitor containing an inside vacuum pump associated with an alpha semiconductor detector that employs energy discrimination to count the daughters of radon 222 and thoron (radon-220).This tool has widely been used in the recent water studies; (Abojassim *et al*., 2017; Al-Hamidawi, 2015). The RAD-7 can be considered as an absolutely machine controlled and moveable element detector, capable of running endlessly for days. An important demand of this method is that the air stream provided to the unit remains dry (humidity < 10%).

Statistical analysis. Two-way ANOVA test was used for further statistical analyses together with correlation analysis. The value $P<0.05$ was considered statistically significant. All statistics were performed using Microsoft Excel 2007.

Results and Discussion

The study area is known to be affected by the local weather of middle part of Iraq which is variable from cold in winter to dry hot in summer; this associated with a moderate temperature during spring and autumn. Figure 2 illustrates monthly variations of air temperature in the research area. The highest values of the temperature were recorded in April at the sixth stations (34 °C), while the lowest value was seen in January at the first station (10.4 °C). Figure 3 shows the monthly variations of water temperature in the studied area. The highest value was recorded in April at the sixth station (28.5 °C) and the lowest value in January was seen at the first station (9.8 °C). The temperature during the present study was recorded at measurement time and does not represent the variation during the whole day.

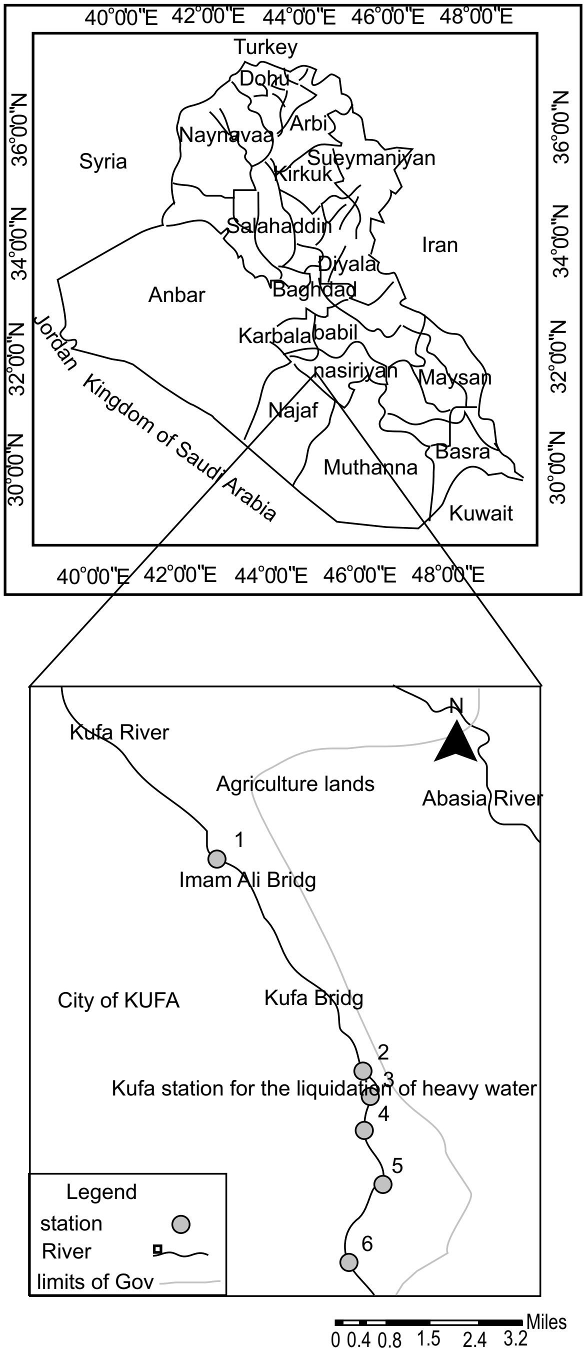

Fig. 1. Base map of the study stations.

Air and water temperature were clearly variable in relation to the weather conditions during measurement time.

The monthly variations of pH were found to be between 5 and 8.5 for stations 1 and 2 during November and February, respectively. The pH findings demonstrate a narrow range in the selected stations due to its high

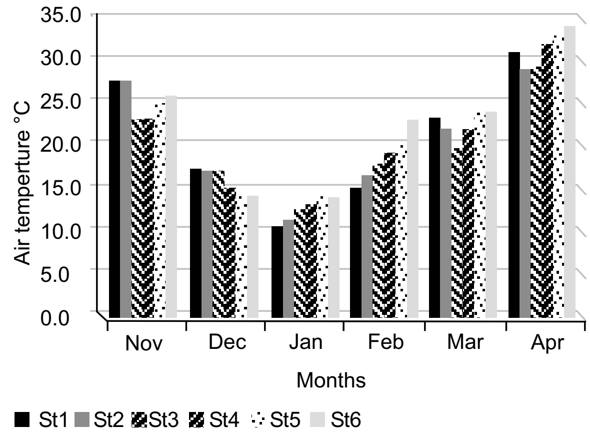

Fig. 2. Monthly variations of air temperature (mean) in study stations.

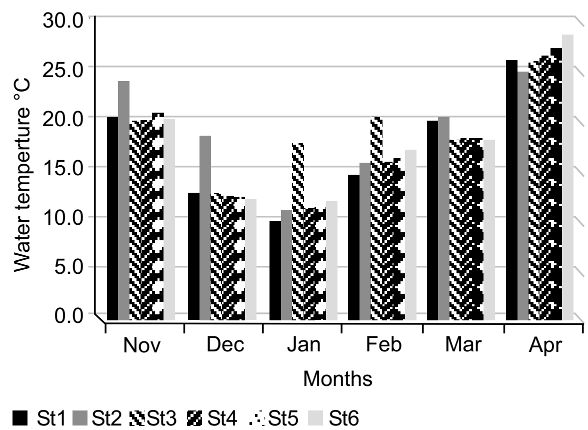

Fig. 3. Monthly variations of water temperature (mean) in study station.

ability to be regulated in hardness water and rich alkalinity with bicarbonates (i.e. buffer system) (Goldman and Horne,1983) and showed in Fig. 4. The value of pH decreased in station 2 during November due to the drainage of the domestic wastes from Barrakhia treatment plant across the river that contains a large amount of wastes which would be expected to affect the pH levels. High proportions of electrical conductivity, salinity and total dissolved solid values were recorded in station 2 as (2963 µs/cm, 1.9 ppt. and 1491 mg/L), respectively during February in Fig. 5-7. The electrical conductivity is an important factor through which estimation of the total salts in water can be obtained (Table 1). Water in station 1 was fresh but in station 2 was brackish which would indicate that the domestic wastes have a marked impact in increasing

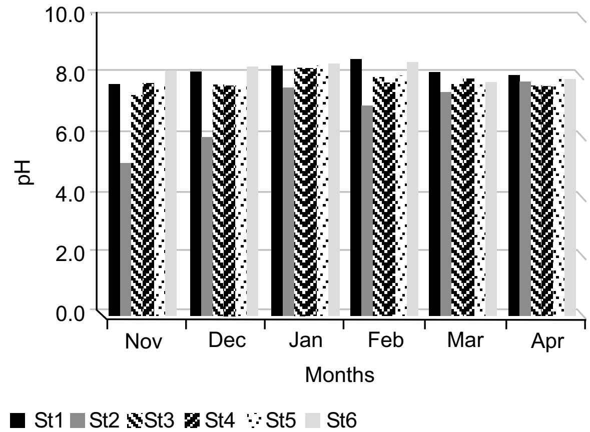

Fig. 4. Monthly variations of pH (mean) in study station.

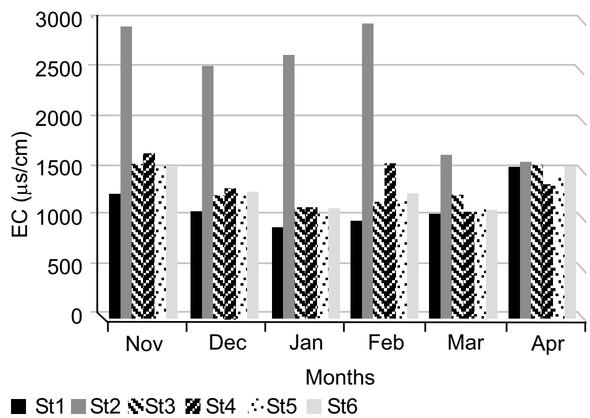

Fig. 5. Monthly variations of electrical conductivity (mean) in study station.

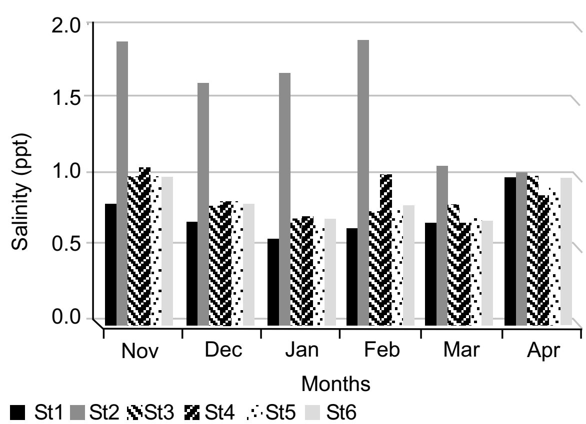

Fig. 6. Monthly variations of salinity (ppt) (mean) in study station.

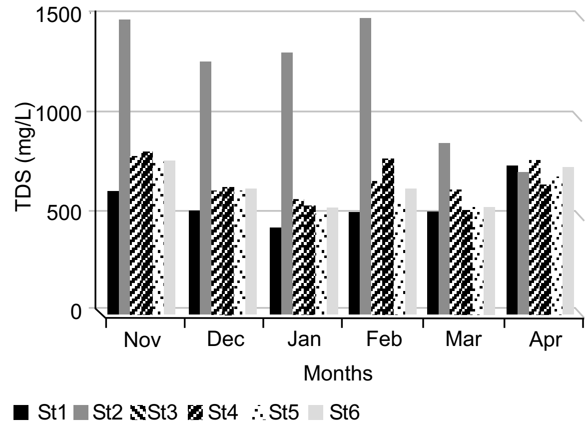

Fig. 7. Monthly variations of total dissolved solid (mean) in study station.

the electrical conductivity, salinity and total dissolved solid values of the river (Al-Zurfi *et al*., 2010). Figure 8 demonstrates the monthly recorded variations of turbidity where a high rate can be seen in station 2; this can be attributed to the amount of drainage of domestic wastes plant to the river and the growth of high numbers of microorganisms which has a positive relation to the turbidity. In this regard, Wetzel (2001) referred to the DO in water that has essential role in the metabolic processes of all aquatic organisms. The oxygen is added to water from atmosphere or due to photosynthesis processes of phytoplankton and aquatic plants (Wetzel and Linkens, 2000). It is well known that the DO is a limiting factor to the growth of much of aquatic organisms (Douabul *et al*., 2013). Variation in the levels of the DO can be attributed to the variation in temperature

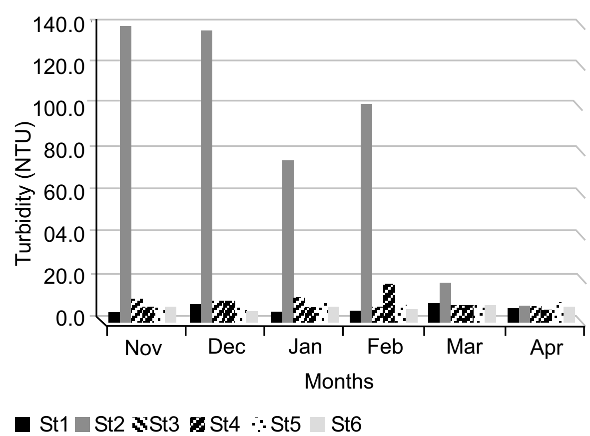

Fig. 8. Monthly variations of turbidity (mean) in study station.

(Haward, 1998), pressure and different ions concentration in water (Wetzel and Linkens, 2000). This study reveals that there is a clear depletion in the DO values at station 2 which is below the detection limit (DL) during November (Fig. 9), this is owing to the decrease in water level and decay processes of organic material which may be caused by the drainage of domestic wastes in this station (Al-Saadi *et al*., 1999). However, DO increase in other stations during February could be attributed to good aeration, continuous mixing, high water level and decrease of temperature during this month (Hassan, 2004) as seen in Table 1. The biological oxygen demand (BOD_5) refers to consumptive amount of oxygen of the added organic material to water that are destroyed by microorganisms. This has a negative effect on the quality of water (Wiener, 2000). The results demonstrate that the rise in the BOD values in station 2 during March was 6 mg/L than in (Fig.10) which is exceeding the acceptable international limit of 5 mg/L (WHO, 1996). This can be attributed to the direct addition of domestic wastes from Barkyia plant to the river. This finding agrees with (Al-Zurfi *et al*., 2010; Al-Mousawi *et al*.,1995). The recorded BOD values in the present study was found to be high compared with results of the Euphrates river at Simawah city (Mushkor, 2002) and lower than the values obtained by Salman (2006) in Euphrates river at Hindhia city. Total hardness values were found in the range between (160 and 1347) mg/L in station 6 and 2 during March and December in Fig.11, respectively. The results demonstrate that the total hardness during the study period was higher than the total alkalinity concentration which may be attributed to the amount of Ca^{+2} and Mg^{+2} ions that affected the total hardness (Lind, 1979), where the rise in the Ca^{+2}, Mg^{+2} ions and bicarbonates in the north area of Iraq is owing to the soil nature, rise of sodium, chloride, sulphates and carbonate ions compared with the south. This change is concurrent with groundwater nature that has a level in medium and southern areas (Al-Lami *et al*., 1999; Talling, 1980). The findings of this study are well agreed with many previous studies that were concerned with rise of total hardness in Iraqi water (Al-Zurfi *et al*., 2010; Salman, 2006).

This study mostly shows that the Ca^{+2} concentration is higher than that of Mg^{+2} as in Fig. 12. This is because the reaction of CO_2 with Ca^{+2} is higher and stronger than the reaction with Mg^{+2} ions, and large amount of Ca^{+2} is converted into dissolve bicarbonates, which

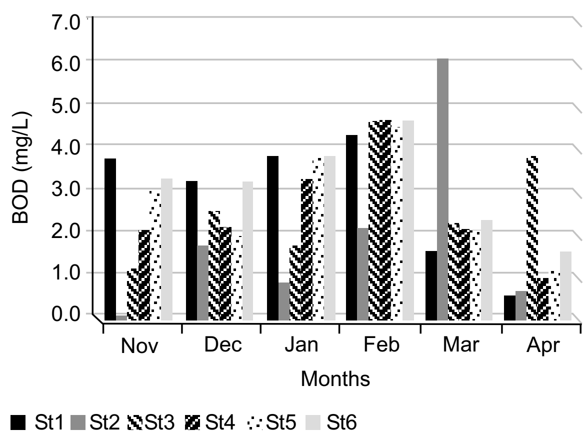

Fig. 10. Monthly variations of biological oxygen demand (mean) in study station.

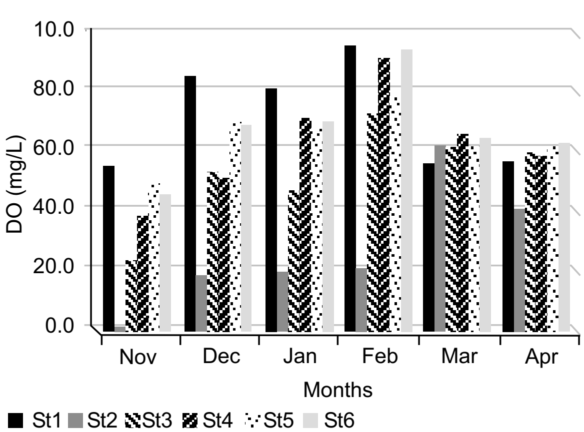

Fig. 9. Monthly variations of DO (mean) in study station.

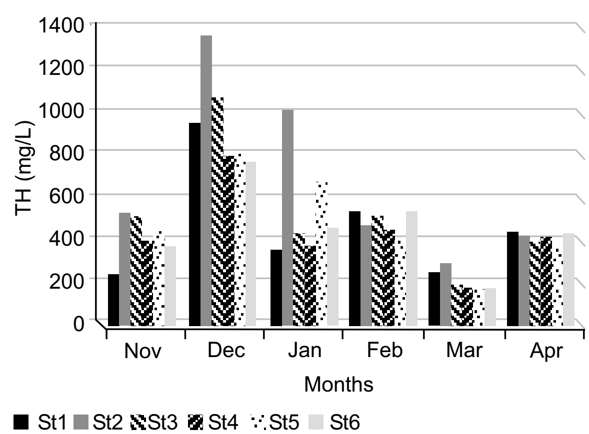

Fig. 11. Monthly variations of total hardness (mean) in study station.

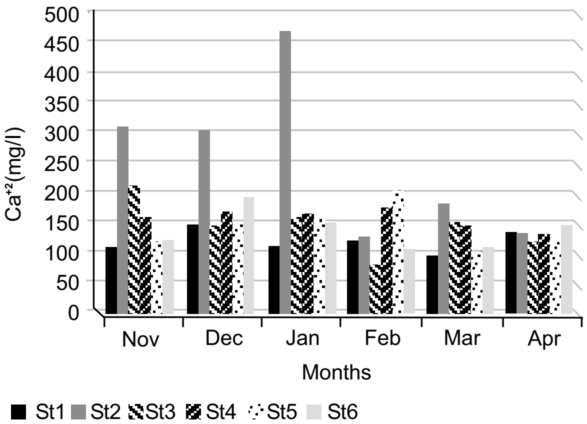

Fig. 12. Monthly variations of Ca^{+2} hardness (mean) in study station.

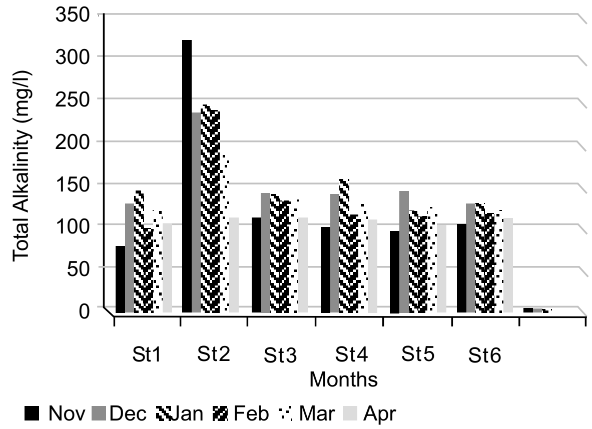

Fig. 14. Monthly variations mean of total alkalinity in study station.

affects on the hardness level as reported by Kassim (1986). The high concentration of Ca^{+2} shows in some stations of Mg^{+2} ions in Fig. 13. This is due to driftage processes from adjacent soil or flowage caused by the domestic and industrial wastes (Al-Lami *et al*.,1999) or may be due to the presence of huge numbers of phytoplankton (Maulood and Al-Mousawi, 1989). In the present study, no carbonate is reported, whereas the hydroxide alkalinity of the river is high due to high bicarbonates which was high in station 2 during November at 323 mg/L and low in station 1 during February at 99 mg/L as showed in Fig. 14.

The high value of alkalinity of the river can be attributed to the rise of temperature and increasing decay rates of organic material which would increase the conversion of insolvent Ca^{+2} carbonate to bicarbonate (Hassan *et al*., 2004). The expectant rate of total alkalinity in natural water is ranged from 20 to 200 mg/L (APHA, 1985). It was observed in the present study that the results are within this range and slightly higher; similar findings were also observed with the bicarbonates alkalinity level. The latter findings were agreed with that of previous studies when alkalinity in Iraqi water was taken into account which could be explained by presence of bicarbonate salts in water and adjacent soil recorded (Al-Lami *et al.*, 1999; Al-Saadi *et al*.,1996; Maulood *et al.*,1994; Sabri *et al*., 1989; Al-Nimma,1982). In term of radon investigation, a positive correlation was found between the Ca^{+2}, Mg^{+2} and radon concentrations at 0.88 and 0.67, respectively as showed in Fig. 15. The investigation also revealed that the maximum radon

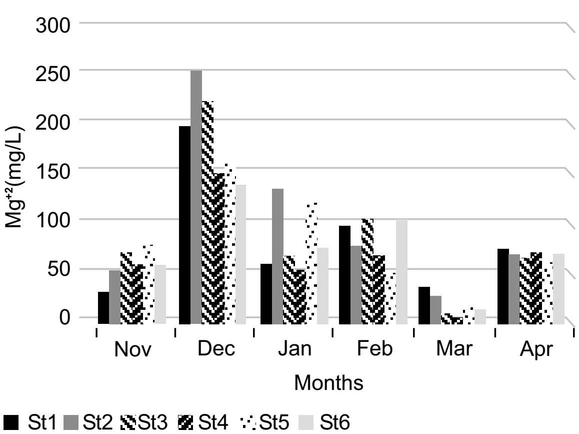

Fig. 13. Monthly variations of Mg^{+2} hardness (mean) in study station.

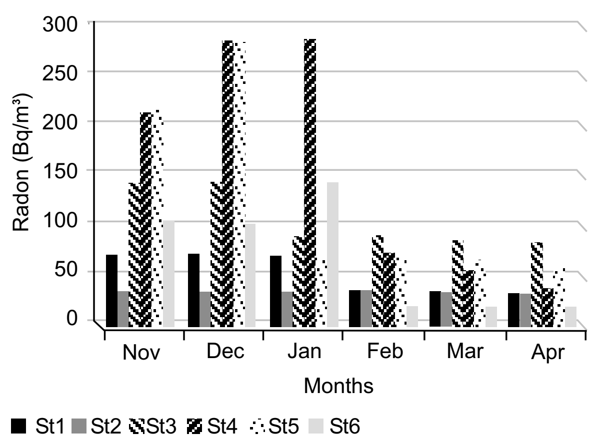

Fig. 15. Monthly variations of radon (mean) in study station.

Table 1. Correlation beteen physical and radiation properties during study period.

	W.temp	A.temp.	pH	EC	Salinity	TDS	Turbidity	DO	BOD	T.H	Ca^{+2}	Mg^{+2}	T. Alk.	Radon
W.temp	1.00	0.99	-0.37	0.34	0.34	0.28	-0.53	-0.3	-0.59	-0.46	-0.69	-0.49	-0.97	-0.56
A.temp.	0.99	1.00	-0.46	0.36	0.36	0.30	-0.49	-0.36	-0.61	-0.53	-0.68	-0.47	-0.94	-0.50
pH	-0.37	-0.46	1.00	-0.68	-0.68	-0.67	-0.45	0.73	0.41	-0.01	0.03	-0.11	0.19	-0.40
EC	0.34	0.36	-0.68	1.00	1.00	0.99	0.57	-0.54	-0.14	0.16	0.06	0.16	-0.27	0.31
Salinity	0.34	0.36	-0.68	1.00	1.00	0.99	0.57	-0.54	-0.14	0.16	0.06	0.16	-0.27	0.34
DO	-0.30	-0.36	0.73	-0.54	-0.54	-0.50	-0.27	100	0.66	0.04	-0.36	0.09	0.07	-0.52
BOD	-0.59	-0.61	0.42	-0.14	-0.14	-0.04	0.34	0.66	1.00	0.01	-0.04	0.02	0.45	-0.13
T.H	-0.46	-0.53	-0.01	0.16	0.16	0.15	0.63	0.04	0.01	1.00	0.62	0.99	0.53	0.73
Ca	-069	-0.68	0.03	0.06	0.06	0.07	0.58	-0.36	-0.04	0.62	1.00	0.53	0.78	0.88
Mg	-0.49	-0.47	-0.11	0.16	0.16	0.15	0.60	0.09	0.02	0.99	0.53	1.00	0.46	0.67
T.Alk.	-0.97	-0.94	0.19	-0.27	-0.27	-0.20	0.60	0.07	0.45	0.53	0.78	0.46	1.00	0.69
Radon	-0.56	-0.50	0.40	0.31	0.31	0.32	0.79	-0.52	-0.13	0.73	0.88	0.67	0.69	1.00

W.temp= water temperature; A.temp= Air temperature; T. Alk= Total alkaline; T. H= Total hydroxide alkalinity

concentration was in December, 2015 at station 4 was 284 Bq/m^3 which is within acceptable limit as indicated by WHO (1996).

Conclusion

In the present study the analytical data of various physicochemical properties indicate that some parameters such as EC, hardness, BOD, turbidity, and total dissolved solids found to be higher than the prescribed limit in some water samples as compared to WHO (1996). The Barrakhia treatment plant affected the water quality of the river during wastes drainage that sometimes occurs directly without treatment and this is incompetent with waste treatment process. However, the radon concentration in water can be considered as safe therefore no doubt can be raised due to radon.

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