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Evaluation of Nitrogen, Phosphorus, Salt Content and Dissolved Oxygen Contamination of Some Groundwater in Amik Plain (Southern Turkey)

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***Abstract*-Amik Plain is one of the most important and productive agricultural areas of Turkey. It was aimed to determine nitrate (NO_3^-), ammonium (NH_4^+) and phosphorus (P) concentration and dissolved oxygen (DO) and salt content (SC) to assess its pollution levels in groundwater of Amik plain. A total of 42 groundwater samples were collected from wells and were analyzed for temperature (T), salt content (SC), dissolved oxygen (DO), ammonium (NH_4^+), nitrate (NO_3^-), and phosphorus (P). The temperature, SC, DO, NH_4^+, and NO_3^- parameters were measured in situ immediately. Phosphorus was determined using ascorbic acid method. Descriptive statistical analyses were calculated to characterize distribution of data of groundwater. Correlation analysis was also used to assess the possible relationships among the parameters. Result shows that the highest and lowest coefficient of variation occurred for P (PO_4^{3-}) respectively. The T, DO, SC, NO_3^-, NH_4^+ and P values in the groundwater ranged from 18.70-29.20 ^oC, 1.57-6.69 mg L^{-1}, 0.22-7.56 g/L, 1.04-42.20 mg L^{-1}, 0.18-6.89 mg L^{-1} and 0.35-203.50 µg L^{-1}, respectively. The 13 of 42 groundwater samples exceeded the permissible limit of 25 ^0C suggesting for very high quality classes. The DO concentration in all samples found lower than the permissible limit of 8 mg/L for high quality classes. Inthis research, NO_3^- contents of all the samples are lower than the desirable limit of 50 mg/L. In only one samples, NH_4^+ contents was higher than the permissible limit of 6.44 mg L^{-1} recommended by FAO. All the groundwater examined samples in this research were lower than $PO_4^=$ limits of 6130 µg L^{-1} by FAO. There were positive and negative correlations between some parameters. Dissolved oxygen deficiency was the main problem in the all examined groundwater in Amik Plain.**

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***Key words*-Amik Plain, Nitrate Pollution, Groundwater, Dissolved Oxygen.**

I. Introduction

Water is very vital for nature and can be a limiting resource to human and other living beings. Water of adequate quantity and quality is required to meet growing household, industrial, and agricultural needs [1]. Groundwater is the most important natural resource utilized for drinking, irrigation, and industrial activities in arid and semiarid areas [2].

Due to the scarcity of surface water in many regions around the world and the rapid increase in the population, there has been sharp increase in the potable water demand. Groundwater is becoming an important source of drinking water supply. The value of groundwater depends not only in its availability but also in its consistent good quality. Many previous studies on groundwater quality have shown that nitrate is derived from various point and nonpoint sources of pollution, such as agricultural, urban and industrial activities. The application of nitrogen-based fertilizers is the most extensive human source of NO_3^- in shallow groundwater systems. The amount of nitrate leached from agricultural lands is strongly influenced by factors inherent in nature such as soil type, groundwater depth and climate conditions [3].

Groundwater water quality degradation as well as other factor often depends on the use of nitrogen fertilizers. Nitrate (NO_3^-) is very soluble and readily leaches to groundwater or drainage tiles when fertiliser or manure application rates are greater than plant nutrient needs [4]. Phosphorus is the principal limiting nutrient in fresh waters and in excess it is responsible for anthropogenic eutrophication. Agricultural systems also contribute to excessive phosphorus (P) additions that are adversely affecting water sources worldwide [5]. Dissolved oxygen (DO) is required to convert biodegradable organic matter from one form to another by living organisms mainly bacteria to maintain the metabolic process and produce energy for their growth and reproduction [6].

In this research, nitrate (NO_3^-), ammonium (NH_4^+), phosphorus (P) concentrations and salt content (SC) and dissolved oxygen (DO) values of some groundwater in the Amik plain were determined and were assessment their pollution levels.

II. Materials and Methods

Amik Plain is located in the province of Hatay (Turkey) and has a total area of 75,000 ha. The study region is lying between latitudes $35^0$48’ and $36^0$37’ and longitudes $35^0$47’ and $36^0$24’. It is surrounded by Amanos Mountain in the west, Syria in the east, the towns of Hassa and Kırıkhan in the north, and the city of Antakya and the town of Altınozu in the south (Fig. 1). The area has a Mediterranean climate with annual average temperature, rainfall and relative

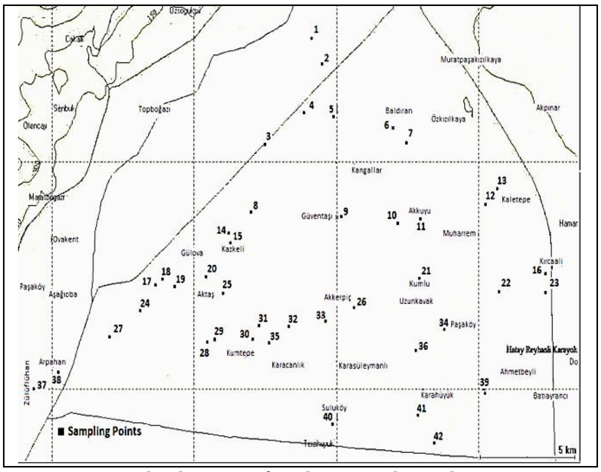

Fig. 1 Geographic location of study area and sampling points

humidity 18.8°C 1124 mm and 69% respectively [7]. A total of 42 groundwater samples were collected from wells and were analyzed for temperature (T), salt content (SC), dissolved oxygen (DO), ammonium (NH_4^+), nitrate (NO_3^-), and phosphorus (P). The temperature, SC, DO, NH_4^+, and NO_3^- parameters were measured in situ immediately with YSI Professional plus instrument (Pro Plus). Phosphorus was determined using ascorbic acid method in the laboratory by using spectrophotometer (Shimatzu UVmini/1240). Descriptive statistical analysis such as minimum (Min), maximum (Max), mean, median (Med), standard deviation (SD) and coefficient variation (CV %) was conducted to characterize distribution of data of groundwater. In addition, correlation analysis was also used to assess the possible relationships among parameter. All statistical analyses were made by using SPSS software (version 17.0).

III. Results and Discussion

Among groundwater parameters, the coefficients of variations (CV) were the highest for P (138.7%) and the lowest for T (12.6%) (Table 1). Low CV values indicate a homogeneous distribution of soil variables, while high CV values indicate a non-homogenous distribution of variables in the study area. (Table 1).

In order to assess the contamination of groundwater regarding physicochemical

Table 1. Descriptive statistics for physicochemical properties (n =42)

	Min	Max	Mean	Med	SD	CV
T oC	18.70	29.20	23.56	22.9	2.96	12.6
DO mgL^{-1}	1.57	6.96	2.92	2.6	1.16	39.7
SC gL^{-1}	0.22	7.56	1.46	1.0	1.48	101.4
NO_3^- mg L^{-1}	1.04	42.20	7.03	4.3	8.70	1238
NH_4^+ mgL^{-1}	0.18	6.89	1.60	0.94	1.53	95.6
P μgL^{-1}	0.35	203.50	23.86	17.8	33.09	138.7
PO_4^{3-} μgL^{-1}	1.07	623.65	73.12	54.6	101.42	138.7

parameters, nitrogen and phosphate, çontents were compared with [8], [9] and [10].

The temperature values in the groundwater are ranged between 18.7 (well no. 34) and 29.2 ^{0}C (well no. 12). In 31.0% of the samples, T values exceeded the permissible limit of 25 ^{0}C suggested for very high quality classes by [9]. Touhari et al. [11] found similar T values with our findings. In this study, it was found that the DO value of the groundwater samples varied from 1.57 (well no. 6) to 6.96 mg L^{-1} (well no.18). The DO concentrations in all samples were found lower than the permissible limit of 8 mg/L for high quality classes [9]. Al Kuisi et al. [12] found similar results in Northern Jordan.

The minimum SC value (0.22 g L^{-1}) was determined in well no. 38 while the maximum SC (7.56 g L^{-1}) in well no.35. There was no reference value for SC. But, the groundwater which the salt contents are above 1.5 g L^{-1} may cause salinity problems in soils and may affect plant growth. 8 of 42 samples have salt contents higher than 1.5 g L^{-1}. Isa et al. [13] found that the SC and DO of the groundwater in Terengganu (Malaysia) are in the range 0.15 to 0.33 g L^{-1} and 1.23 to 11.08 mg L^{-1}, respectively.

The lowest NO_3^- concentration (1.04 mg L^{-1}) has been recorded in well no. 38 while the highest NO_3^- concentration (42.20 mg L^{-1}) has been determined in wells no. 16 in this study area. None of the samples from the study area exceeded the desirable limit of 50 mg L^{-1} and 44.5 mg L^{-1} for NO_3^- recommended by WHO and FAO, respectively. Zaidi et al. [14] found similar results with our findings while another research by Gu et al. [15] nitrate concentration over there exceed FAO limits in North West China. The NH_4^+ values in groundwater ranged from 0.18 mg L^{-1} (well no. 36) to 6.89 mg L^{-1} (well no. 21). In only one sample, NH_4^+ content was higher than the permissible limit of 6.44 mg L^{-1} recommended by FAO. On the other hand Chinnasamy and Hubbart [16] found very low NH_4^+ concentrations in central USA.

The P values in groundwater ranged from 0.35 µg L^{-1} (well no. 31) to 203.5 µg L^{-1} (well no. 21). It has not been established a health-based guideline water value for P in drinking water by [8]. But the Food Standards Agency [17] determined guideline value for P in drinking water and FAO determined the maximum recommended concentration for P in irrigation water. According to [17] and [10], PO_4-P limit are 2200 and 2000 µg L^{-1}, respectively. None of the groundwater samples in this research exceeded these both P limits. The reason of this situation is to be very low solubility of the phosphorus in the soil [18]. Our findings of phosphorus concentrations are in disagreement with results by Vincy et al. [19].

Correlation Analysis

It was found that there was a negative correlation between NO_3^- and T ($p<0.05$). The salt content (SC) was positively correlated with NO_3^- and NH_4^+ ($P<0.01$). In addition a positive correlation was found between NO_3^- and P (PO_4^{3-}) at 0.0 levels (Table 2).

Conclusion

Groundwater resources are very important for Amik Plain. Because, rainfall is not sufficient in summer season in the

Table 2. Correlation between parameters

	T	DO	SC	NO_3^-	NH_4^+
DO	-0.050				
SC	-0.279	-0.081			
NO_3^-	-0.354*	0.220	0.345*		
NH_4^+	-0.081	0-.052	0.355*	-0.058*	
P	-0.251	-0.001	-0.073	0.667**	-0.020
PO_4^{3-}	-0.251	-0.001	-0.073	0.667**	-0.020

plain, therefore, surface and groundwater are used as the main sources of the irrigation in the research area in the summer season.

Sometimes, drainage water is also used for irrigation purpose when the other sources became inadequate. In addition, the peoples who live and work in this area use well water as drinking purpose. Because of these reasons, groundwater quality is very important in Amik plain. The results indicated that there was no NO_3^-, NH_4^+ and PO_4^{3-} pollution in the groundwater of research area. Despite temperature and salt content seemed to be problems in some of the groundwater and dissolved oxygen deficiency were the main problem in the all examined groundwater in Amik Plain.

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