Original article

Human impact of septic tank effluent on groundwater quality in the rural area of Ain Soltane (Ain Defla), Algeria

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ABSTRACT

The impact of individual septic tank effluent on groundwater quality was investigated in the rural area of the Ain Soltane municipality in Algeria. This area has an important number of individual septic tanks, and it is devoid of a drinking water supply and sewerage systems. The septic tank is a pre-treatment solution of sewage by bacteria living without oxygen (anaerobic). The alluvial aquifer in this area is covered by a layer of good permeability on the surface, which can pollute groundwater by vertical transport of pollutants through the soil, including microbial contamination. Groundwater samples were collected from 33 wells in the dry period of 2016. The monitoring of groundwater quality has shown a significant degree of organic and inorganic pollution in the majority of wells, with very high concentrations of sulphate and chloride exceeding 450 mg/l and 250 mg/l respectively. The analyzes also show the presence of bacterial germs in the groundwater of which the origin is faecal (faecal coliform densities are above 10 organisms per 100 ml, and the Total Streptococcus is more than 240 colonies per 100 ml). Monitoring confirms the contamination of these wells from septic tanks and that it was moving into groundwater, which makes it unfit for drinking due to the pathogenic germs. This poses a major problem for public health. This study has identified the effects of septic tank effluent on groundwater quality in this area.

KEY WORDS: groundwater quality, septic tank effluent, pathogenic bacteria, Ain Soltane

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1. Introduction

Numerous diseases influencing the world's population are connected to the contamination of surface water or/and groundwater from untreated domestic and industrial wastewater. The nature of the cleared water has been increased since industrial development, economic and population development (REAY, 2004). According to the World Health Organization (WHO, 2008), 75% of illnesses of the population on the planet are connected to water contamination (ODUKOYA & ABIMBOLA, 2010; AL-KHARABSHEH ET AL., 2013; ODUKOYA ET AL., 2013). As a consequence the control and monitoring of water quality, specifically wastewater, are becoming very necessary. Without treatment, this wastewater

constitutes a major risk to human health and to the natural environment due to their toxic chemical component and to pathogenic microorganism loads (HANCHAR, 1991).

The microorganisms have the ability to migrate through the soil matrix, that increase the probability of groundwater contamination. Moreover, there are numerous sicknesses caused by bacteria, such as diarrhea, dysentery, cholera, and typhoid fever.

The use of septic tanks in rural areas as a system of wastewater treatment contributes directly to the contamination of groundwater (REDDY & DUNN, 1984). These are the largest systems used in rural areas in Algeria, thus, it is important to know and understand the impact of sewage effluent infiltration from septic tanks on the quality of groundwater,

especially in the alluvial unconfined aquifer. Septic tanks are built to treat human wastewater, and to attenuate organic matter, and microorganisms. They are placed in the unsaturated zone, which can purify water due to this zone. At an average flow of 0.15 m³/day, septic tanks are a significant source of effluent recharge, with a large concentration of nitrogen and phosphorus, and they can in some cases attenuate nitrogen, but are ineffective at attenuating pathogens, organic matter and phosphorus (YATES, 1985; FUBARA-MANUEL & JUMBO, 2014; PANDEY ET AL., 2014). The transport of solute through soil depends closely on the purifying power of the soil. The different pollutants constitute permanent dangers to both human and animal health and even to the soil and plants (ROBERTSON & CHERRY, 1992; LUOSTARINEN & RINTALA, 2007).

The aim of this work was to determine the concentrations of nitrate, chloride, and sulphate in the groundwater samples in the alluvial unconfined aquifer of Upper Cheliff, to evaluate the effect of septic tank effluent on the groundwater quality and to check the role of the unsaturated zone as a natural system of wastewater purification.

2. Study area

The Upper Cheliff plain is located approximately 120 km south west of the capital Algiers, between 36°10' and 36°20' north latitude and 02°00' and 02°25' east longitude and covers an area of 375 km². The plain is confined between the massif of Zaccar in the north and the Ouarsenis chain in the south. The alluvial plain of Upper Cheliff is characterized by a Mediterranean semi-arid climate, with hot dry summers and cold rainy winters. The annual average temperature for the period of 1980-2014 was 19°C, and the precipitation average for the same period was about 400 mm. The estimation of the real annual evapotranspiration by the Thornthwaite method gives a value of 328 mm, while runoff estimated by the Tixeront-Berkaloff method gives a value of 40 mm, however, the infiltration is about 32 mm. The hydrographic network of the study area is extremely dense. The most significant Wadis are the main Cheliff Wadi and its tributaries like Deurdeur, Harreza, Boutane, Erraihane, Telbanet and Massine. Three dams were built on the periphery of the Upper Cheliff plain: Ghrib, Harreza and Derdeur. These dams and the groundwater of the alluvial aquifer contribute to the irrigation of the agricultural plain with more than 20,000 ha irrigated.

The larger part of the Upper Cheliff plain is occupied by vegetables and tree crops and the other parts are used for cereals. The irrigation is ensured

by private drillings and by a pressure network supplied by dams. The groundwater of the Upper Cheliff plain is used for drinking, irrigation, and industrial purposes.

The study area is located in a rural agglomeration of the Ain Soltane province, which located in the south of this province. We note that, the neighboring cities of the plain have wastewater discharges towards the stream of the wadi Cheliff river, due to the absence of a wastewater treatment plant, whereas the rural agglomerations use individual septic tanks for the discharge of wastewater, which represents one of the main environmental problems facing the plain, due to its impact on superficial and groundwater resources (Fig. 1).

This rural agglomeration with about 10 000 inhabitants spread over an area of about 3000 hectares, has no network systems for drinking or for sewerage. The local inhabitants use private wells for drinking supplies and septic tanks to discharge wastewater.

Fig. 1. Diagram of sewage percolation and transport from the septic tank to pumping well

3. Geological framework

The Upper Cheliff plain is elongated in an east-west direction within the Tellian Atlas (Fig. 2). The stratigraphical succession in the study area from the older to recent formations is the following (BOUDERBALA, 2017; BOUDERBALA & GHARBI, 2017):

- The Permian-Triassic is observed in the Zaccar and Doui massifs and is formed by an alternation of black schist, clays and quartzites;
- The Triassic is characterized by massive gypsum and dolomite formations;
- The Jurassic in the Zaccar massif is mainly underlain by sedimentary rocks of limestone, dolomite and other carbonate rocks. Its thickness can reach 1000 m. While the Jurassic rocks in the Doui massif are formed mainly of dolomitic limestones;
- The Cretaceous outcrops on the lateral borders of the plain are represented by the following series:

- A series of Neocomian schists with a thickness of about 1000m;
- Gray schist alternating with benches of quartzite of Albian-Aptian, with a thickness near to 1000 m;
- It is intercalated by yellowish limestone of the Senonian.
- The Miocene formation is about 300 m in thickness. The Lower Miocene is essentially formed by quartzites, sandstones and schists. It is surmounted by Burdigalian (Middle Miocene) with sandstone, conglomerates and marls. The Mio-Pliocene is formed of limestones, sandstones, conglomerates, clays and the sandstones of Gontas, with a thickness about 100 m.
- Old alluvial deposits are represented by conglomerate and pebbles.
- The calcareous crust is formed by calcareous tufa whitish, compact or powdery. It is especially developed in the southern boundary of the Cheliff plain.
- The cone of detritic deposits (alluvial cone) is developed on the slopes of the boundary of the plain; it is formed of material washed down on the slopes of mountains by ephemeral streams.
- The recent alluvial deposit is formed of pebbles, gravels, clay and silt which is covered by an organic soil. There are also alluvial deposits observed near the beds of wadi Cheliff.

Fig. 2. Geology of the study area

1 – recent alluvial deposits; 2 – cone of detritic deposits; 3 – calcareous crust; 4 – old alluvial deposits; 5 – sandstones and conglomerate (Miocene and Pliocene); 6 – clays, sandstone, conglomerate (Middle Miocene); 7 – marls and clay (Lower Miocene); 8 – sandstones and schists (Eocene); 9 – flyshs (Cretaceous); 10 – limestones (Jurassic); 11 – sandstones and schists (Permian and Triassic); 12 – metamorphic rocks (Paleozoic)

4. Hydrogeology

The principal aquifer in the Upper Cheliff plain is formed by alluvial deposits, including pebbles, gravels, sands and clay formations; with a thickness of between 50 and 150 m. It is a confined aquifer in the major part of the plain because it's covered by silt and clay on the surface, with a thickness from 5 to 20 m, but this aquifer is unconfined in the study area.

The alluvial aquifer is overlain by the Mio-Pliocene formations, as are the sandstones which occur in the northeast at Gontas and in the southeast in Ain-Lechiekh.

The Mio-Pliocene formations can reach 200 m in thickness. Thus, the Mio-Plio-Quaternary formations have been considered as a multi-layer aquifer system. The hydraulic continuity between these formations indicates a continuity in some area and separation by clay lenses in the other part of

the area. In this study, we are interested only in the quaternary alluvial aquifer. The groundwater of this alluvial aquifer flows from the north and south of the plain towards the centre, where the main drainage axis is located, which coincides with Wadi Cheliff, and the main flow of groundwater is from east to west.

The water table depth measurements vary from 5 m in the west zone (near to Djendel) to 30 m in the east zone (near to Arib and Djelida), with an average depth of 10 m in the central part of the plain. The pollution of groundwater in the region may originate from domestic, agricultural or industrial activities.

The only significant recharge source for the aquifer is the effective infiltration and the irrigation water return. The movement of large volumes of groundwater (quality of recharge) through the highly permeable alluvial aquifer, while rapidly diluting chemical contaminants, may allow the transport of micro-organisms in septic tank effluent over large distances.

5. Sampling and physicochemical analysis of groundwater

A total of 33 groundwater samples was collected from wells in the study area during October 2016. The locations of these groundwater sampling wells are shown in Fig. 3. The water table depths were measured with a water level meter, they vary approximately from 10 m in the upstream to 18 m in the downstream during the dry period. It should be noted that water table elevations fluctuate between dry and wet periods.

The water samples were collected after pumping for 10 to 15 minutes in order to remove stagnant groundwater. Physical parameters such as pH, total dissolved solids (TDS) and electrical conductivity (EC) were measured in the field by a conductivity meter using the standard procedures. The samples were then analyzed in the laboratory of Algerian waters (ADE). The analyzed parameters included four cations (Mg^{2+} , Ca^{2+} , Na^+ and K^+) and four anions (SO_4^{2-} , Cl^- , HCO_3^- and NO_3^-). The samples were subjected to computation of ionic-balance-error between the total concentrations of cations and anions, for the interpretation of the chemical data. The value of the ionic-balance-error was observed to be within the acceptable limit of $\pm 5\%$.

Water samples for bacterial analysis were collected in sterile 100 ml bottles, stored at $4^\circ C$ until analysis, which occurred within 8 hrs of collection. Four bacteriological parameters were analyzed: Faecal Coliforms, Total Faecal Streptococci and Total Coliforms were analyzed by the membrane

filtration method. Coliforms are specific type of bacteria which inhabit the intestines of humans and other warm-blooded animals. The presence of faecal coliforms in large numbers of water samples is indicative of human contamination.

Fig. 3. Sampling points in the study area

6. Results and discussion

The results of microbiological and geochemical testing of ground water of extraction wells are presented in Tables 1.

6.1. General hydrochemistry analysis

Septic tanks contribute to nonpoint source pollution through the direct introduction of contaminants such as pathogenic bacteria, nutrients and organic matter and indirectly by freshwater inputs, which can result in enhanced contaminant transport as well as the survival of microbial agents. The shallow water table depths and permeable gravels of the study area, which are typical of many alluvial plains, represent a high-risk setting for groundwater contamination due to the domestic wastewater discharge. As mentioned in the literature (REAY, 2004; AL-KHARAB SHEH ET AL., 2013; FUBARA-MANUEL & JUMBO, 2014), raw domestic sewage has high concentrations of dissolved solids, such as sodium, chloride, nitrogen, phosphate and organic constituents with low pH.

Table 1. Results of physico-chemical analyzes (October 2016)

Puits	pH	CE μS/cm	TDS (mg/l)	O ₂ (mg/l)	Ca ²⁺ (mg/l)	Mg ²⁺ (mg/l)	Na ⁺ (mg/l)	K ⁺ (mg/l)	Cl ⁻ (mg/l)	SO ₄ ²⁻ (mg/l)	HCO ₃ ⁻ (mg/l)	NO ₃ ⁻ (mg/l)	TH (°F)
P1	7.39	2180	1230	6.8	280	80.8	165	3.5	546.7	560.3	250.1	23	103.7
P2	7.03	3256	1640	6.2	224	84.8	164.5	4.3	541.2	531.5	246.1	20	83.8
P3	7.54	3026	1541	5.1	208	88.6	158.5	8.3	436.6	606.5	262.3	15	88.9
P4	7.48	2571	1440	6.7	194	83.7	117.5	4.7	388.2	512.7	262.3	24	83.4
P5	7.33	2416	1335	6.1	168	73.7	147	3.5	434.6	374.9	286.7	23	72.7
P6	7.67	2360	1352	7.1	160	58.3	131.5	3.5	360.8	276.7	275	25	64.3
P7	7.8	2204	1256	9.3	168	52.9	139.5	3.6	415.5	299.5	237.9	26	64.1
P8	7.59	2309	1350	8.9	172	46.2	123.5	3.2	360.8	175.6	219.6	31	62.3
P9	7.47	2506	1440	6.9	188	78.3	132.5	3.9	382.7	310.4	244	34	79.7
P10	7.78	2450	1441	7.1	176	68.6	155	3.3	486.6	315.4	256.2	35	72.6
P11	7.25	2017	980	7.4	180	38.9	110.5	3.8	311.6	221.2	244	30	61.2
P12	7.18	1880	944	8.3	156	34.0	102.5	2.7	295.2	210.8	219.6	25	53.2
P13	7.24	1969	950	8.9	168	36.7	107.5	2.1	322.5	263.4	225.7	28	57.3
P14	7.34	2058	1019	8.9	188	38.9	106	2.7	333.5	175.6	244	31	63.2
P15	7.34	2000	997	8.7	172	46.2	101	2.8	344.4	224.2	189.1	37	62.3
P16	7.42	2115	1052	8.5	180	46.2	105.5	2.5	366.3	186.5	219.6	35	64.3
P17	7.35	2281	1130	8.3	212	46.2	101.5	3.0	382.7	321.9	225.7	38	72.3
P18	7.28	3017	1510	8.4	252	75.3	142.5	2.4	617.8	262.4	201.3	40	94.4
P19	7.24	2924	1464	7.3	268	82.6	127	2.7	568.6	312.4	231.8	35	101.5
P20	7.33	2188	1079	8.5	201	48.6	115.5	3.2	388.2	115.6	219.6	31	70.3
P21	7.46	3407	1753	8.7	276	106.9	160.5	3.1	688.8	184.0	207.4	39	113.6
P22	7.23	3257	1661	8.7	284	77.4	149	2.5	579.5	194.0	219.6	43	103.3
P23	7.35	2926	1488	8.9	252	82.6	146.5	2.5	628.7	97.8	242.8	53	97.5
P24	7.28	3298	1683	8.7	316	112.3	141.5	2.7	639.6	267.8	206.7	35	125.8
P25	7.31	2522	1280	8.4	244	58.3	111.5	2.6	404.6	213.8	183.0	51	85.3
P26	7.39	2266	1139	9.0	244	59.03	128.5	2.3	493.6	109.7	186.4	55	85.6
P27	7.22	4015	2066	7.5	348	143.3	176	3.5	524.3	615.8	257.4	53	146.8
P28	7.25	3907	2016	7.7	322	133.6	195	3.0	736.5	481.6	234.2	56	136.2
P29	7.27	4044	2087	7.9	268	116.0	189.5	4.6	732.6	312.4	244.0	52	115.4
P30	7.46	2183	1096	8.6	202	75.3	103	2.6	366.8	251.5	231.8	51	81.4
P31	7.37	1857	927	8.5	188	53.5	94	2.5	322.6	218.8	219.6	60	69.3
P32	7.24	2053	1030	8.7	224	65.6	100	2.7	349.9	191.7	219.6	62	83.4
P33	7.46	3235	1649	9.6	288	116.6	144	2.8	606.8	361.2	200.8	65	120.6
Max.	7.8	4043.5	2087	9.6	348	143.3	195.0	8.3	736.5	615.8	286.7	65.0	146.8
Min.	7.03	1857.2	927.0	5.1	156.0	34.0	94.0	2.1	295.2	97.8	183.0	15.0	53.2
Average	7.37	2627.3	1364.4	8.0	223.4	73.0	133.1	3.3	465.4	295.7	230.7	38.2	86.0
SD	0.17	633.4	329.8	1.1	52.8	28.5	27.4	1.1	131.1	140.9	24.8	13.4	24.0
Norm of WHO 2011	6.5 – 8.5	1500	1000	5	200	150	200	12	500	250	500	50	53
% > norm	0	100	84.8	0	57.6	0	0	0	36.4	57.6	0	30.3	100

The main physico-chemical parameters of groundwater are given in Table 1. The pH of the groundwater of the study area ranged from 6.8 to 7.3 with an average value of 7.1, indicating slightly alkaline conditions. This may be attributed to anthropogenic activities such as sewage disposal, wastewater disposal and use of fertilizers in agricultural lands in this area. The temperatures were about 19.5°C over the study period. The dissolved oxygen concentrations of the groundwater showed values less than 5 mg/l, while the limited dissolved oxygen data indicated an anaerobic, or near anaerobic, conditions (< 5.0 mg/l).

Although, the electric conductivity (EC) ranged from 1915 to 3730 μS/cm, with an average value of 2627 μS/cm, which exceeds the standard limit of EC in drinking water of 1500 μS/cm (WHO, 2008). It seems that the groundwater in the study area is classified as brackish water (Table 2). The high values are probably due to anthropogenic activities and geological weathering conditions giving higher concentrations of dissolved minerals. These high values of EC (EC > 1500 μS/cm) reveal enrichment of salts in groundwater.

The Total Hardness (TH) varies from 53.2 to 146.8°F indicating that the groundwater belongs to the very hard water category of all samples

(TH > 53°F) (Table 3). Total dissolved solids (TDS) values of groundwater samples ranged from 927 mg/l to 2087 mg/l, with an average of 1364.4 mg/l, indicating that the majority of samples fell within the quality of water not desirable for drinking (Table 4).

Table 2. Classification of groundwater for drinking based on EC (Subba Rao et al., 2012)

EC ($\mu\text{S}/\text{cm}$ at 25 °C)	Classification	Number of samples	% of samples
< 750	Desirable	0	0
750–1500	Permissible	0	0
1500–3000	Not permissible	23	69.7
> 3000	Hazardous	10	30.3

Table 3. Classification of groundwater for drinking based on TH (WHO, 2008; Brindha & Elango, 2012)

TH (°F)	Type of water	Number of samples	% of samples
0–7	Pure water	0	0
7–14	Soft	0	0
14–22	Water moderately soft	0	0
22–32	Water moderately hard	0	0
32–53	Hard	0	0
> 53	Very hard	33	100

Table 4. Classification of groundwater for drinking based on TDS (Davis & DeWiest, 1966)

TDS (mg/L)	Type of water	Number of samples	% of samples
< 500	Desirable for drinking	0	0
500–1000	Permissible for drinking	2	6.1
1000–3000	Useful for irrigation	31	93.9
> 3000	Unfit for drinking and irrigation	0	0

For the cations, the concentrations of Ca^{2+} , Mg^{2+} , Na^{+} and K^{+} range from 156 to 348 mg/l, 34 to 143.3 mg/l, and from 94 to 195 mg/l, respectively. Similarly, the concentrations of anions Cl^{-} , SO_4^{2-} , HCO_3^{-} and NO_3^{-} varies from 295.2 to 736.5 mg/l, 97.8 to 615.8 mg/l, 183 to 286.7 mg/l and from 5 to 40 mg/l, respectively.

The most common sources of Ca^{2+} and Mg^{2+} , in groundwater, are through the dissolution of rocks, such as limestone (calcareous crust) and minerals, such as calcite and magnesite. High levels of calcium in drinking water have some negative health effects; they promote vascular degeneration (arteriosclerosis) and osseous degenerative changes (osteoarthritis). The majority of the wells in this

area have high concentrations of Ca^{2+} (more than 54% of samples exceeded the norm) compared to WHO standard. Sodium is also present in most rocks and soils, as well as in many foods and human activities. The contents of Na^{+} increase if the residence time in groundwater increases. In the study area, the concentrations of Na^{+} are less than the 200 mg/l, limit recommended by WHO.

In general, groundwater rarely has potassium (K^{+}) levels more than 10 mg/l. The potassium results from the alteration of silicate formations (gneiss and schist), potassic clay and the dissolution of chemical fertilizers (intensive fertilization used in agricultural activities, NPK); it can also result from domestic and industrial discharge. In the study area, all samples had concentrations less than 10 mg/l.

Figure 4 shows an increase of Ca^{2+} and Mg^{2+} concentrations from downstream to upstream in this area. This is due to the dissolution of the calcareous crust located on the surface combined with the shallow depth of the piezometric levels of groundwater.

The excess of Cl^{-} in the groundwater of this area (100 % of samples exceeded norm WHO standards) may be related to the anthropogenic effect, with a high probability of the impact of wastewater coming from traditional septic tanks used by inhabitants in this rural area.

The higher values which have been observed in the south part of the study area (upstream wells), are due to the shallow depths of the water table (Fig. 5).

While, the excess of SO_4^{2-} concentrations in groundwater in the majority of samples (more than 57%) is due to the effect of the use of fertilizers in agriculture, the evaporation, dissolution of gypsum observed in the marl substratum, it is also comes from untreated wastewater coming from traditional septic tanks. The higher values which have been observed in the north part of the study area (downstream wells), are due to the effect of flow direction of groundwater (Fig. 5). The higher levels of sulphates can cause health hazards, particularly gastro-intestinal problems.

The concentrations of NO_3^{-} indicate values from 5 to 40 mg/l in this part of the plain, this is due to the use of fertilizers in agricultural activities.

The high HCO_3^{-} concentrations in this area are mainly derived from the dissolution of carbonate minerals and from CO_2 present in the atmosphere and in soil above the water table (unsaturated zone). It can be due to the occurrence of oxidation of organic matter of the soil (ODUKOYA & ABIMBOLA, 2010).

Fig. 4. Distribution of the Ca^{2+} , Mg^{2+} , and Na^{+} cations in the study area

Fig. 5. Distribution of the Cl^{-} , SO_4^{2-} and HCO_3^{-} anions in the study area

6.2. Interpretation of bacteriological assessment

The bacteriological test results (Table 5) indicate that the eight groundwater samples analyzed contained total coliforms above the permissible level (> 10 colonies per 100 ml of water). This may indicate a recent contamination of groundwater in this aquifer by human sewage or animal faeces which could contain other bacteria, viruses or disease causing organisms. Coliforms and streptococci are the bacteria whose presence in the eight groundwater samples which constitute a clear indication of contact between faecal matter and groundwater in the alluvial aquifer in this area. These results confirm the impact of septic tanks on groundwater,

which poses a serious problem for the health of people in this rural area.

6.3. Groundwater types

A Piper diagram (PIPER, 1944) was established for the groundwater in this area using the hydrochemical analysis data (Fig. 6). In the present study, the concentrations during the dry season (October 2016, Table 1) show the order of abundance of the major cations: $\text{Ca}^{2+} > \text{Na}^{+} > \text{Mg}^{2+}$ and the abundance of the major anions: $\text{Cl}^{-} > \text{SO}_4^{2-} > \text{HCO}_3^{-}$ thus the totality of the samples is plotted in the Ca-Cl type. The evaluation of water type by using the Piper diagram suggests the dissolution of carbonate rocks, added to the anthropogenic effect coming from the wastewater of traditional septic tanks.

Table 5. Results of bacteriological analyzes (October 2016)

Parameters		Total Coliforms (colonies/100 ml)	Fecal Coliform (colonies/100 ml)	Fecal Streptococci (colonies/100 ml)	Total Streptococci (colonies/100 ml)
Wells	P1	14	10	–	> 240
	P2	20	14	–	> 240
	P3	25	17	–	> 240
	P4	22	15	–	> 240
	P5	20	12	–	> 240
	P6	28	20	–	> 240
	P7	34	24	–	> 240
	P8	34	24	–	> 240

Fig. 6. Piper trilinear diagram plot of the groundwater samples (October 2016)

7. Conclusion

The hydrochemical analysis showed the poor groundwater quality, due to the existence of pollution in the area, resulting from the excess of chlorides, sulphates, calcium and nitrates. This pollution can have two origins, one natural and the other anthropogenic.

The bacteriological analysis of the groundwater shows a high concentration of Total Coliforms, Faecal Coliforms, and Faecal Streptococci, which confirms the contamination of the groundwater by the domestic wastewater discharge. The septic tanks, make nonpoint pollution via the infiltration of contaminants such as pathogenic bacteria, nutrients and organic matter.

The results suggest possible contamination of groundwater from septic tank due to the short distance between wells the septic tanks, the low depth of piezometric levels of groundwater, and the high permeability of the unsaturated zone in this rural area.

The septic tank systems which have been used in this rural area in Ain Soltane, are regarded as the most efficient method for treatment of domestic wastewater, but in fact, they are one of the potential sources of groundwater pollution.

Generally speaking, the groundwater from all the wells is not portable; which can raises serious public health concerns for the people of this area if consumed.

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