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Assessment of the Physicochemical Characteristics and Heavy Metals Level Groundwater at Setif High Plains (Algeria)

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Abstract: The present study aims to analyze the physical and chemical characteristics including heavy metals from groundwater in the industrial zone of Ain El Kebira in the district of Setif (Algeria) during the years, 2007 and 2008. The pH ranged from 6.8-9, the temperature ranged from 19.5-21.4°C, turbidity ranged from 0.15-4.52 NTU, the hardness was estimated between 19.8-39 mg L^{-1}. The conductivity was estimated at 581-1154 sec cm^{-1}. Nitrate ranged from 16.8-69.82 mg L^{-1}, nitrite 0.01-0.89 mg L^{-1}. Chlorides ranged from 56.8-125 mg L^{-1}. Heavy metals analyzed by atomic absorption spectroscopy revealed that the concentrations of Fe were estimated between 0.315-1.388 mg L^{-1} that of Zn 0.02-0.558 mg L^{-1}, Cd between 0.001-0.006 mg L^{-1} and Pb between 0.013 and 0.661 mg L^{-1}. According to the results, the waters sampled were moderately hard. The pH, turbidity, temperature and chloride were within standards. Nitrates and nitrites station 3, 4.5 and 6 were the most affected because they are close to farmland and domestic discharges of residents. The levels of heavy metals in the samples show that Zn and Cd exhibited values acceptable by those cons of Pb and Fe were above the required standards. This groundwater must be monitored regularly to protect the health of residents who have only those wells for drinking water.

Key words: Pollution, groundwater, physical and chemical, heavy metals, Setif, Algeria

INTRODUCTION

Water has long been regarded as an inexhaustible resource, it is essential to life but is scarce everywhere. On the planet, in fact, >1 billion people are <20 L day^{-1} which is very little to live (Hertig, 2006). The exploitation of water resources is very intense with the increasing needs of a population explosion in developing countries. Pollution from heavy metals poses a potential for contamination of groundwater by an industry that develops without worrying about the harm caused to the environment in all its forms. By getting rid of pollutants in soil, we think we finally got rid of. In reality, they are just hiding and it pollutes groundwater tables. Many African countries will experience water shortages during the next 25 years if steps are not taken for a preservation of water reserves. The Northern Algeria has a semiarid climate characterized by a highly irregular rainfall; extreme seasonal and interannual irregularity is accentuated by long periods of drought. However, 65% of the distributed drinking water is drawn from groundwater by drilling or sources. Groundwater is a natural resource for drinking water in Algeria and Africa. In the wilaya of Setif, staffing is 140 L/jour/capita that are below the WHO standard of 250 L/day/capita. In Africa, several studies have shown that industrial units polluting the water intended for human consumption from wells and boreholes adjacent industrial units such as cement plant in Cotonou-Benin (Zohoun *et al*., 1993). Research in the area and Guelma Berrahal (Annaba) in Algeria have shown that surface water and groundwater from industrial areas contaminated with heavy metals (Khelfaoui *et al*., 2008). Researchers can talk about the fight against pollution by heavy metals in Algeria because it is still in the stages of findings and diagnoses. It is within this context that we found it useful to elucidate for the first time in the highlands Setif groundwater pollution by heavy metals in a region dominated by an industry represented the last 30 years by the cement industry (SCAEK) and bolts, valves and cutlery (BCR). This region is very important from an environmental perspective because it is adjacent to National Park Babors which is a

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protected reserve and universally Oued Ezzatine which is a wetland. The present study is to analyze the physicochemical characteristics (hardness, conductivity, pH, temperature, turbidity, nitrate, nitrite and chloride) and the heavy metal content (Fe, Zn, Cd and Pb) by atomic absorption spectroscopy groundwater to determine their qualities not only for human consumption but also for irrigation.

In the absence of mains supply drinking water to residents are forced to use water from wells and boreholes for their daily needs.

MATERIALS AND METHODS

Overview of the study area: Ain El Kebira is located about 30 miles North of the town of Setif in Northern Algeria, between latitude 36°36'N and longitude 5°5'E. The people of Ain El Kebira are estimated at 56,703 inhabitants spread over an area of 19,592 km^2 with a density of 2.89 inhabitants km^{-2}. The occupation is represented by two very important sectors: Agriculture cereal with a useful area of 2953 ha and industrial activity composed of the following industrial units: Cement, BCR, tile factory and a manufacturing unit cinderblock.

The climate of the study area is Mediterranean semi-arid, it spreads to the sub humid with two seasons: rainy and cold Winter another Summer long, dry and warm. Rainfall is very irregular but relatively large. The annual rainfall is around 600 mm. The region of Ain El Kebira is a mountainous region which is experiencing a steady snowfall during the Winter with 15 days of snow $year^{-1}$. The annual average is estimated at 47 days of frost $year^{-1}$. The winds coming predominantly from the Northwest sector can be very cold during Winter, Spring and Summer; the region suffers from Southerly winds and hot dry negatively impacting the local vegetation and causing significant erosion. Thus, the Sirocco is common in Summer and absent from November until February is characterized by abnormally high temperatures and humidity low the wind always blows from the mainland to the Mediterranean sea.

Sampling: Samples were collected at the stations represented by the wells in the industrial zone of Ain El Kebira. Researchers collected water in a glass bottle of 1000 mL sterilized with 10% nitric acid, until the volume has been replaced 3 times (Reseaerchers let the water run to remove impurities and not to incorporate air bubbles).

The physical-chemical tests were performed at the laboratory of Electrochemistry, University of Setif for heavy metal, researchers used atomic absorption spectroscopy for the National Products of Setif (ENPEC):

- In station 1, El Kherba 1000 m East of the BCR wells of an individual as a source of drinking water
- In station 2, about 500 m North-East of the BCR it is not a particular well controlled by the services of the ADE
- In station 3, about 500 m East of the cement is not controlled by the services of the ADE
- In station 4, about 1000 m East of the cement unit level tiles on the road to career
- In station 5, about 500 m South of the plant
- In station 6, about 750 m West of the cement. A first set of was chosen in the scope of the industrial zone and shows by 6 stations from March-October of 2007 due to a levy for 2 months. A 2nd phase consists with drawls for December, 2007 to July, 2008 to a levy for 2 months at 4 stations

Analysis: It was to measure the temperature on site, hardness, conductivity, pH, nitrates, nitrites, chlorides and heavy metals (Fe, Cd, Pb and Zn).

The hardness: The hardness or total hardness the hardness of water is the sum of the concentrations of metal cations and in most cases the calcium and magnesium ions. The technique allows the determination of alkalinity (Lenntech, 2004).

Conductivity: Conductivity is the property that has a suspension to promote the passage of an electric current. It is due to the presence of ions that are mobile in an electric field. It depends on the nature of these ad dissolved ions and their concentration. The temperature affects the conductivity because the mobility of ions proportional to the temperature. The conductivity type is inoLab WTW® Cond 730.

The pH: The pH is used to quantify the concentration of ions of water that gives it its acidic or basic. The apparatus used is a pH-meter WTW pH meter type 521.

Temperature: The water temperature is a parameter of comfort for users. It whose values are related to temperature as the conductivity been measured using a thermo-hygrometer field type Chauvin Arnoux CDA 845.

Turbidity: Measuring the turbidity of the water we provide information on its load of suspended solids. It is linked to its transparency and was measured by a portable turbid meter Hach 2100Q type.

Table 1: Analysis of physical and chemical characteristics of groundwater during the first phase in the 6 stations

		Parameters					
Levis	Stations	Hardness (mg L^{-1})	Conductivity (µsec cm^{-1})	pH	Nitrates (mg L^{-1})	Nitrites	Chlorides
L1	1	21.0	751	7.4	44.24	0.43	71.0
	2	20.2	658	7.1	50.91	0.89	71.0
	3	38.0	1056	7.8	61.58	0.27	56.8
	4	32.1	1024	7.7	62.58	0.37	100.6
	5	30.8	953	7.6	70.80	0.97	103.6
	6	20.8	564	6.8	63.58	0.22	56.8
L2	1	22.4	759	7.4	49.50	0.59	71.0
	2	20.5	659	7.1	52.45	0.21	72.0
	3	36.0	1060	7.9	69.59	0.61	56.4
	4	38.2	1050	8.1	69.82	0.45	114.2
	5	28.0	975	7.9	65.14	0.15	99.4
	6	19.8	571	7.1	65.80	0.18	58.3
L3	1	24.0	775	7.5	49.21	0.11	72.0
	2	21.4	668	7.2	54.90	0.15	74.0
	3	39.0	1091	8.5	74.17	0.09	57.4
	4	33.8	1150	8.4	79.50	0.14	125.2
	5	32.0	1100	7.9	69.42	0.19	121.0
	6	22.4	581	6.8	66.40	0.17	59.7
L4	1	21.0	752	7.5	43.45	0.21	70.0
	2	22.1	661	7.2	52.91	0.02	71.0
	3	36.4	1072	7.4	79.10	0.13	56.9
	4	31.2	1080	7.6	63.23	0.18	119.2
	5	30.6	1051	7.2	61.20	0.15	111.4
	6	21.4	565	7.1	65.50	0.14	58.4

Nitrates and nitrites: The analytical method applied for the determination of nitrates and nitrites is based on a technique of molecular absorption spectrophotometer by streaming.

Chlorides: The chloride contents of the waters are extremely diverse and mainly related to the nature of the ground. The assay was performed by the Mohr Method.

Heavy metals: The analysis by flame atomic absorption spectroscopy type Perkin Elmer, Analyst 3110 (PAC) of a sample solution is fed into a flame-drying, volatilization and transforms the sample into a cloud of atoms neutral.

The light emitted by a hollow cathode lamp of the specific analytic passes through the flame and the neutral atoms of the same element absorb a portion of the light thus reducing the intensity of the light beam (Table 1).

RESULTS AND DISCUSSION

Industrial discharges are the source of the contamination of surface water and groundwater. To highlight the influence of these releases from the cement and RCC were analyzed physical and chemical characteristics and concentration of heavy metals (Fe, Zn, Cd, Pb and Cu) in groundwater is the sole source supply drinking water for the inhabitants of the region of Ain El Kebira. The results compared with the WHO standards, EEC and Algerian (Table 2).

Table 2: Standards WHO, EEC and Algerian groundwater

Physic-chemical parameters	ECE standards	WHO standards	Algerian standards
Hardness (mg L^{-1} $CaCo_3$)	25	20	50
Conductivity (µsec cm^{-1})	250-1000	250-1000	400-1000
pH	6.5-9	6.5-9.5	6.5-8.5
Turbidity (NTU)	<5	<5	<5
Nitrites (mg L^{-1})	0.1	0.02	0.1
Nitrates (mg L^{-1})	50	50	50
Chlorides (mg L^{-1})	200	250	500
Fe (mg L^{-1})	0.2	0.3	0.3
Zn (mg L^{-1})	5	3	5
Cd (mg L^{-1})	0.005	0.003	0.05
Pb (mg L^{-1})	0.01	0.01	0.05

Table 3: Physical and chemical properties of groundwater during the second phase for the 4 stations

		Parameters					
Levies	Stations	Conductivity (µsec cm^{-1})	pH	T°C	Turbidity (NTU)	Nitrites (mg L^{-1})	Nitrates (mgL^{-1})
L1	1	828.00	7.2	19.9	4.52	0.02	21.6
	2	672.00	6.9	19.5	1.86	0.01	36.2
	3	1185.00	7.7	19.6	0.94	0.01	46.0
	4	1045.00	7.6	19.6	0.29	0.01	39.0
L2	1	853.00	7.1	20.8	7.48	0.01	29.2
	2	734.00	6.9	20.1	1.95	0.00	69.5
	3	1120.00	7.6	20.2	1.05	0.01	66.4
	4	1105.00	7.5	19.9	0.96	0.12	39.0
L3	1	718.00	7.2	20.8	2.93	0.01	27.5
	2	1091.00	7.5	19.9	0.52	0.00	22.1
	3	1154.00	7.8	20.2	0.15	0.15	36.9
	4	1058.00	7.8	19.8	2.15	0.01	21.5
L4	1	9.19	7.1	21.4	3.58	0.01	16.8
	2	689.00	7.6	21.1	2.48	0.09	47.1
	3	1106.00	7.7	20.9	1.59	0.08	38.2
	4	1061.00	7.5	20.8	1.98	0.03	29.6

Hardness: The for the hardness or under Hydrometric are shown in Table 3. The results showed that the hardness is between 19.8 and 39 mg L^{-1}. The waters of station 3 are the hardest.

If we consider the WHO and EEC standards researcher can say that the water is hard and this is due to the very nature of the limestone soils on the one hand and release of the cement in the form of $CaCO_3$ on the other. By cons when referred to Algerian standards researcher concluded that researchers are in the standards because they are too tolerant (Brigitte *et al*., 2003).

Conductivity: The conductivity is shown in Table 1 and 3. It is between 581 and 1154 sec cm^{-1}. Station 3-5 were most affected and had higher rates than standard limits (between 250 and 1000 sec cm^{-1}) and >1000 sec cm^{-1}

mineralization is very strong so rich in minerals. This confirmed their positions near the cement plant.

The pH: The pH is between 6.8 and 9 has revealed that these values are within permissible levels. Station 3 and 4 had an alkaline pH near the upper limits because of their situations terraced cement.

Temperature: It is shown in Table 3 and ranged from 19.5-21.4°C. Researchers found that we were in the required standards (25°C), EEC, WHO or Algerian. However, the station 1 has always been high temperatures compared to other stations because it borders the warm water discharges of BCR.

Turbidity: All stations were in the standards, so <5 NTU except station 1 which has been influenced by discharges of suspended solids in the BCR and residents. Nitrates and nitrites the concentrations of nitrates and nitrites which are shown in Table 1 and 3 ranged from 16.8-69.82 mg L^{-1}. These are the station 3-6 which presented the highest rates, exceeding the threshold allowed 50 mg L^{-1}. They are close to farmland character cereals loaded with fertilizer and the consumer release of people who do not have sewerage. These discharges go directly to Oued Ezzatine, stream that feeds mainly groundwater in the region of Ain El Kebira. Just as the nitrite levels were very high and exceeded the standards Algerian least stringent 0.1 mg L^{-1}. The instability of nitrates and nitrites affecting this region is due to lack of awareness among farmers who use fertilizers chaotically.

This increased level of nitrates and nitrites are the result of cement dust pollution which affected the water table and what prompted these farmers to do so in order to increase their performance. The performance was evaluated at 3 quintals ha^{-1} whereas it was 25 quintals ha^{-1} before the establishment of these industrial units.

Chlorides: The rate of chloride which varied between 56.8 and 125 mg L ha^{-1} were below standard or WHO (250 mg L ha^{-1}) or EEC (200 mg L ha^{-1}) which are most severe in relation to Algerian standards (500 mg L ha^{-1}). So chlorides did not constitute a risk of groundwater contamination.

Heavy metals: These are primary pollutants persistent, their life in soil is 1700 years; they can be accumulated in food chains. The concentrations of heavy metals are shown in Fig. 1 of the 6 stations during the first phase of sampling. Table 3 shows the average concentrations of heavy metals in the 4 stations selected to monitor their progress during this second phase.

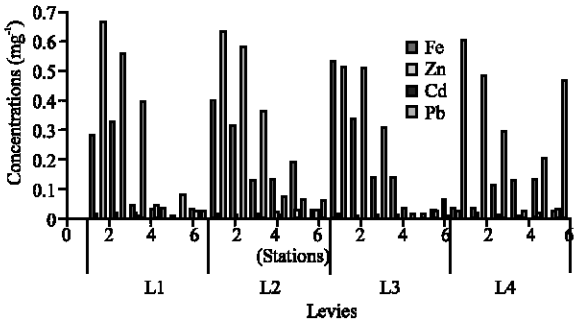

Fig. 1: Analysis of heavy metals concentration (mg L^{-1}) in ground water during the 1st phase in the 6 stations

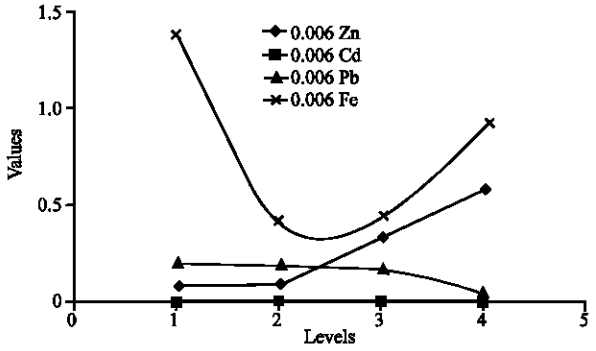

Fig. 2: Mean values of heavy metals during the 2nd phase for the 4 stations

Fe: Values ranging between 0.315 and 1.388 mg L ha^{-1} are shown in Fig. 1 and 2. They were above the threshold is 0.3 mg L^{-1}. High levels of station 1 and 2 confirmed that they are close to the BCR which rejects much of toxic waste from surface treatment.

Zn: All sites were below the 5 mg L^{-1}. So, Zn was not a threat to the stations (Davis *et al*., 2001).

Cd: The data disclosed in Fig. 1 and 2 between 0.001 and 0.006 mg L^{-1} showed a pollution limit the stations if they referred to CEE (0.005 mg L^{-1}), WHO (0.003 mg L^{-1}) and Algerian (0, 05 mg L^{-1}). The CD may be a relatively safe if one refers to the Algerian and EEC standards.

Pb: Figure 1 and 2 shows the values of Pb that range between 0.013 and 0.661 mg L^{-1}. Station 1-3 were the most polluted due to discharges of BCR, the addition of cement products and the pollution that leaded gasoline is still used in Algeria. Pb is a very toxic and cause lead poisoning, anaemia and can also cause damage to the brain and nervous system. From the results, researchers evaluated the quality of groundwater in the industrial

zone of Ain El Kebira for the first time. The physic-chemical composition allowed us to sound the alarm when the use of wells for human consumption. However, according to the collation settings of water for irrigation, researchers concluded that these waters can be used for irrigation and in particular on drained soils in association with plants tolerant to salt (Derradji *et al*., 2004).

CONCLUSION

From the analysis, researchers conclude that the cement, the BCR and domestic discharges of residents and farmers have contributed to the contamination of groundwater in the region by nitrates, Pb and Fe exceed the standards of EEC, WHO and Algerians who are even more tolerant. Station 2 and 3 are most polluted and pose an imminent danger to the citizens who continue to feed into drinking water from these wells. Resaerchers can now use this groundwater for irrigation only on well-drained soil and salt tolerant plants. Indeed, techniques for decontamination of polluted aquifers are lengthy, costly and do not restore the drinking water; in this context that we must act quickly to stop the contamination of groundwater in the region when knows that North Africa will be affected by climate change, drought and desertification.

RECOMMENDATIONS

It is imperative to stop all pollution sources by networks and sewage treatment plants for local residents. Strict control of the quantity and quality of fertilizers used by farmers. The absolute prohibition residents to obtain water from wells station 2 and 3. Phytoremediation would be very useful if we want to reduce the accumulation and infiltration of toxic substances in soil and water. An epidemiological survey in the region is needed to detect diseases related to this water. Standards are too tolerant Algerian and it is time to revise them downward to align with those of WHO.

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