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Well water contamination at a mining extract zone near Marrakech city in Morocco

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ABSTRACT

Seasonal variation on physicochemical parameters of well water at Draa Lasfar mining extract area in Marrakech - Morocco was studied. A total of 144 samples, 36 each during four different seasons, winter, spring, summer and autumn were collected during the years 2012-2013 and analyzed for temperature, pH, total hardness, Chemical Oxygen Demand, concentration of nitrate, heavy metals like lead, zinc, and cadmium. Significant difference between seasons was observed for temperature, Chemical Oxygen Demand, concentration of nitrate, zinc and cadmium. Highest temperature (28.72±3.16) was recorded during summer. Chemical Oxygen Demand and zinc concentration was recorded maximum during summer (167.25±31.05 mg/l, 131.4±12.0 µg/l respectively). Highest nitrate (2.67±0.75 mg/l) concentrations were recorded during spring. Highest lead (632.14±82.54 µg/l) and cadmium (1.93±0.36 µg/l) concentrations were recorded during winter.

KEYWORDS

Well water;
Mining extract zone;
Contamination;
Heavy metals.

INTRODUCTION

Water is one of the essentials that supports all forms of plant and animal life[27] and it is generally obtained from two principal natural sources ; Surface water such as fresh water lakes, rivers, streams, and Groundwater such as borehole water and well water[18, 20].

Water is useful for several purposes including agricultural, industrial, household, recreational and environmental activities. Despite its extensive use, in most parts of the world water is a scarce resource.

Unfortunately industrialization and human activities have partially or totally turned our environment into dumping sites for waste materials. As a result, many water resources have been rendered polluted and hazardous to man and other living systems[2].

Water is typically referred to as polluted when it is impaired by anthropogenic contaminants and either does not support a human use, such as drinking water, and/or undergoes a marked shift in its ability to support its constituent biotic communities, such as fish[9].

Deposition of heavy metals in groundwater from anthropogenic activities has been implicated for an increase in heavy metal concentration above recommended levels[1, 3, 24].

The term "heavy metal" is not altogether clearly defined, but in the case of water pollution, these are metals such as arsenic, cadmium, iron, cobalt, chromium, copper, manganese, mercury, molybdenum, nickel, lead, selenium, vanadium and zinc. While heavy metals do tend to have a high atomic mass, and so are heavy in that sense, toxicity seems to be a further defining factor as to what constitutes a heavy metal and what does not.

Heavy metals are important components of agro-allied products such as pesticides, herbicides, fertilizers; manufacturing and other synthetic products such as paints and batteries[26]. Mining activities, industrial, municipal and domestic wastes have been reported to be important sources of heavy metal pollution to the groundwater[15].

Excessive concentration of heavy metals in the groundwater is of great concern because of their non-biodegradability. Therefore, their persistence in the environment portends health hazard plants and animals and consequently trigger ecological imbalance in the ecosystem[8].

Another concern that high concentrations of heavy metals raise is their ability to bioaccumulate across the food chain, with members that are high up the food chain having concentration of such metals several times higher than what is obtainable in the depart point of the contamination (groundwater)[4, 19].

In Morocco, Ground water was main source of water supply in most rural communities. It had good microbiological and biological properties in general as such required minimal treatment. Actually, A variety of human activities, notably industrial and mining process have been responsible for the wider diffusion of heavy metals into this type of water.

This study was carried out to determine the spatial and seasonal variations of heavy metal deposition in groundwater in a mining area near Marrakech city in Morocco in order to assess the extent of pollution generated by the mining activity and to identify the key mechanism responsible for this contamination and its relation to this mining activity.

MATERIALS AND METHODS

Study area

The Draa Lasfar mine is located in northwest of the Mrabtine zone at approximately 10 Km in the west of Marrakech city Figure 1. it’s located a few hundred meters from the Tensift River, close to a rural community of about 5790 ha, which 65% are occupied by farmland. Draa Lasfar consists on deposit of pyrite mineral discovered in 1953 although their commercial exploitation did not begin until 1979. Mineral was processed by flotation after primary and secondary crushing and grinding, producing 60 Mt of products in the first two years (1979 and 1980)[21]. Industrial activity stopped in March 1981, although it restarted in 1999 due to its great resource of polymetallic components (As, Cd, Cu, Fe, Pb and Zn). During its exploitation, tailings were discharge all around the mine area posing a risk for the environment.

Sampling methods and sample preparation

Water samples were collected once a month for twelve months between April 2012 and April 2013.

Water was taken from wells which are falling within 1 km radius of industrial unit of Zn and Pb extraction. Samples were taken directly from wells in sterile glass bottles of 250 milliliters capacity, after rinsing the bottles three times with sample water. In order to collect the samples directly from well, bottle with a string attached to neck was used. Another long clean string was tied to the end of sterile string and the bottle was lowered into the water et allowed to fill up. Then the bottle was raised and stoppered. The collected samples were transported to laboratory in ice within an insulated container and analyzed within 24 hours of collection.

A total of 144 well water samples, 36 each during four different seasons of the year viz. summer (june - august), spring (March-May), autumn (september-december) and winter (january-marsh) were collected during the years 2012 and 2013 and analyzed for physical parameters like temperature and pH, chemical parameters like total hardness, Chemical Oxygen Demand (COD), concentration of nitrate, iron and heavy metals like lead, cooper, zinc and cadmium. Study was carried out in such a way that, same 36 wells were sampled during four seasons.

Temperature and pH of each sample was measured using mercury filled glass thermometer and digital pH meter respectively3. Total hardness of the samples was estimated using Total hardness test kit. Measurement of COD was made photometrically in Spectroquant NOVA 60 (Merck, Germany) after digesting the samples in preheated Thermoreactor TR 320 (Merck, Germany). Concentration of nitrate, iron, lead and mercury in water samples was measured photometrically in Spectroquant NOVA 60 and expressed in mg/l. Estimation of zinc, copper, lead and cadmium was carried out using Atomic Absorption Spectrophotometer.

RESULT AND DISCUSSION

Results of analysis are shown in TABLES 1 and 2.

pH

pH of well water was in the range of 5,78 ± 0,22 - 6,71 ± 0,24, and significant difference between seasons was not observed. pH is mainly influenced by volume of water[17], soil type[17, 7], presence of chemicals and application of acidic fertilizers.

In the present study, pH was not within the acceptable range of pH for drinking water (6.5- 8.5)[28].

- Acid pH of well water during autumn may be due to dissolved carbon dioxide and organic acids such as fulvic and humic acids which are derived from decay and subsequent leaching of plant materials. During dry seasons (summer) there may be death and decay of plants due to lack of sufficient water which increases the organic acid content of water in turn causing acidity.
- The higher pH values during rainy season could be due to high photosynthesis of micro and macro vegetation resulting in production of high CO2, shifting the equilibrium towards alkaline side[12]. This could be attributed to the presence of luxuriant vegetation inside most of the wells during rainy season.
- Temperature

Temperature ranged from 27,5-28,1. Lowest temperature was recorded during winter and highest temperature was recorded during summer, which was in accordance with ambient temperature pattern[11, 1].

Total hardness

Total hardness was in the range of 296.28±37.14 - 423.67±27.88 mg/l, with no significant seasonal variation. Higher total hardness could be due to discharge of effluents and untreated waste[25] from the local extracting mine industry to nearby surface water sources. Highest value of total hardness was observed during summer. It could be due to the low water level and high rate of evaporation during summer[22].

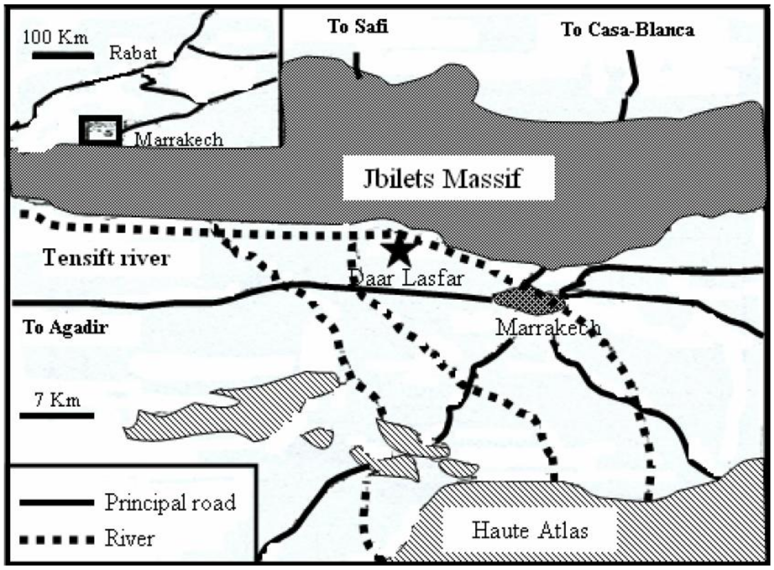
TABLE 1: Physical quality of wells water

parameters	seasons			
	winter	spring	summer	autumn
pH	6.71 ± 0.24	6.56 ± 0.14	6.03 ± 0.17	5.78 ± 0.21
temperature (°C)	27.5 ± 2.07	28.02 ± 3.16	28.72 ± 2.26	28.37 ± 2.68

TABLE 2 : Chemical quality of wells water

parameters	mean concentration during four seasons mg/l			
	winter	spring	summer	autumn
Total hardnes	302.56 ± 31.39	296.28 ± 37.14	423.67 ± 27.88	376.15 ± 23.75
COD	96.87 ± 17.37	117.26 ± 57.41	167.25 ± 31.09	115.68 ± 43.16
Nitrates	2.11 ± 0.47	2.67 ± 0.71	1.63 ± 0.23	1.15 ± 0.43
Lead (µg/l)	632.14 ± 82.54	335.45 ± 62.71	512.64 ± 60.85	433.52 ± 71.57
Zinc	80.12 ± 5.51	86.72 ± 6.42	131.42 ± 7.45	103.91 ± 9.25
Cadmium (µg/l)	1.93 ± 0.36	1.68 ± 0.19	1.78 ± 0.37	1.56 ± 0.24

Figure 1 : Drâa Lasfar mine geographic situation in Marrakech region



Chemical oxygen demand

COD ranged from 96.87±17.37 to 167.25±31.05, and showed significant difference between seasons. Lowest and highest values were observed during winter and summer respectively. Higher values of COD indicate the presence of oxidizable organic matter19. The entry of industrial effluents and the agricultural runoff might be responsible for increased level oxidizable organic matter[22]. The higher COD could be due to death and decay of plants and subsequent increase in organic matter during summer[12]. The lower COD observed during winter could be due to the effect of dilution increased by rain at this season.

Nitrates

Mean nitrates concentration of well water was in the range of 1.15±0.43- 2.67±0.75 mg/l, which were within WHO guidelines (2006) for nitrate. Nitrate detected in well water samples might have originated from decaying organic matter[23], discharge of sewage and industrial wastes and runoff from agricultural fields containing nitrate fertilizers[12]. Mean nitrate concentration was lowest during autumn and highest during spring. The highest concentration during spring might be due to application of nitrogenous fertilizers to agricultural land during rainy season and subsequent seepage through soil.

Lead

Mean lead concentration was in the range of 335.45±62.71- 632.14±82.54 µg/l, and was above WHO guidelines, 2006 (0.01 mg/l) for lead in drinking water. This mining extract zone being an industrial area is subjected to the discharge of effluent containing lead to nearby water bodies.

Analysis of waste products[14] generated by this mine extract industry showed that significant amount of lead is generated by this industrial unit in their waste products. The effluents rich in lead are discharged to water bodies nearby and subsequently affect the groundwater quality of the area. It was shown a significant seasonal variation: spring samples showed lowest concentration and respectively winter and summer seasons showed highest concentrations. Combined effect of decreased amount of water in summer and strong leaching during winter might have contributed to higher lead concentration during these two seasons.

Zinc

Mean zinc concentration was in the range of 80.12±5.51 - 131.42 ± 7.45 µg/l, and was within the limit of 500 µg/l as prescribed by WHO guidelines, 2006. The analysis report pointed out that significant amount of zinc is generated by this industrial unit, which in turn deteriorate the ground water quality. The concentration was highest during summer when depletion of water leads to greater concentration of metals[6].

Cadmium

Mean cadmium concentration varied from 1.56±0.24-1.93±0.36 μg/l, and showed significant difference between seasons. Analysis of waste products had shown that this industry discharged some amount of cadmium in their waste products, deteriorating the groundwater quality. Cadmium concentration was found to be highest during winter, which might be due to leaching during this season.

CONCLUSION

Well water quality in the study zone showed seasonal variation for temperature some parameters (pH, COD, concentration of nitrate, zinc, lead and cadmium) and exceeded in most cases the limits prescribed by WHO guidelines 2006. In order to improve quality of well water and consequently to protect people and animals from the perils of well water contamination, it is crucial to initiate measures to check the pollution from industrial effluents and to establish on-site regular well water quality monitoring network stations.

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