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Pollution by heavy metals of sediments of nine water sources of Tyikomiyne region, watershed of Guir (Eastern Morocco)

H.Taouil[1]*, S.Ibn Ahmed[1], A.El Assyry[2], M.Fadli[3], N.Hajjaji[4], A.Srhiri[4]

[1]Laboratory of Organic Synthesis and Extraction Processes, Ibn Tofail University, Department of Chemistry, P.B. 133, 14000 Kenitra, (MOROCCO)

[2]Laboratory of Optoelectronics and Physical Chemistry of Materials, Ibn Tofail University, Department of Physics, P.B. 133, Kenitra, (MOROCCO)

[3]Laboratory of Biodiversity and Natural Resources, Faculty of Sciences Kenitra, P.B. 133, 14000 Kenitra, (MOROCCO)

[4]Laboratory of Electrochemistry and Corrosion Studies and Environment, Ibn Tofail University, Department of Chemistry, P.B. 133, 14000 Kenitra, (MOROCCO)

E-mail : hamidsup@yahoo.fr

ABSTRACT

Water of sources in watersheds is used for drinking and irrigation. But the geological nature of soil in this region promotes a contamination by metallic trace elements such as Fe, Mn, Zn, Cu, Pb, Cr, Co, Ni and Cd found in that region. So, the objective of this work is to determine the environmental impact of these trace elements in assessment of the sediment quality of nine sources in Tyikomiyne, a eastern geographical region of the watershed of "Guir "(Morocco). The spatial variation of contents in trace heavy metals were evaluated in in superficial and profound sediments of nine sources in Tiykomiyne, region of Talssint (East of Morocco). A diagnosis of the current situation of the metal pollution of the sediment is necessary to judge the quality of the water and of its impact on the environment. Results have showed that the deep sediments accumulate more Fe, Mn, Ni and Cr and the decreasing succession of concentrations of studied metals is as following: Fe>Pb>Mn>Zn>Cu>Cr>Ni>Co. In addition, the concentrations of the iron, manganese and lead are above of the norms fixed for the drinking water but levels of these concentrations remain below of the standard of the water irrigation. The high levels of these three metals could be explained by the effect of regional geological context.

KEYWORDS

Pollution;
Heavy metals;
Sediments;
Guir watersheds;
East Morocco.

INTRODUCTION

In the Tyikomiyne area, Talssint region, the water of springs is used for drinking and irrigation, but the geological nature of the soil of the region risk to cause a groundwater contamination by heavy metals and this may limit potential use of gin this roundwater. Indeed, these elements could migrate and reach groundwater, accumulate in the food chain and pose risks to human health [1].

This type of pollution is indeed one of the aspects of the most threatening pollution to receiving media. Its effects are greatly negative. It could lead to dangerous or critical situations affecting among other ecological balance of ecosystems. Thus, the metal contamination of aquatic ecosystems has attracted the attention of many researchers[2-4]. So, Bouabdli et al [5], have been interested in the pollution by heavy metals of the River of Moulouya (Morocco) and have noted an effect in sediments of many metal elements such as Cd, Pb and Zn are higher in sediments analyzed.

For the studied region, a complete diagnosis of the current situation of the metal pollution and rigorous monitoring of its evolution is necessary to judge the quality of sediment sources concerning the metallic elements and their impact on the environment state of this region. So, in this work, we have evaluated the concentrations of nine metal in superficial and deep sediment of 9 water sources in Tiykomiyne which is located in east of Morocco.

Note that water physicochimical of wells in Tyikomiyne and water quality evaluation of the river Tislit-Talssint has been recently reported by our group[6–9].

MATERIAL AND METHOD

Study medium

Region Talssint belongs to the domain of East High Atlas Morocco, part of the region of the eastern, putting this latter in contact and Meknes-Tafilalt and Fes-Boulmane regions[10]. Our study areas concerns sediment sources of Tyikomiyne area, Talssint region which has been no previous academic study[8] and is limited by (Figure 1):

- The agglomerations of Douars (Ezzaouia) in south.
- The quarter (Affia) in north.
- The regional route RP601 towards to (Beni-Tadjit) in the west.
- Jbal Alaajra, in the East.

Bioclimatic level

On the bioclimatic, the region is characterized by

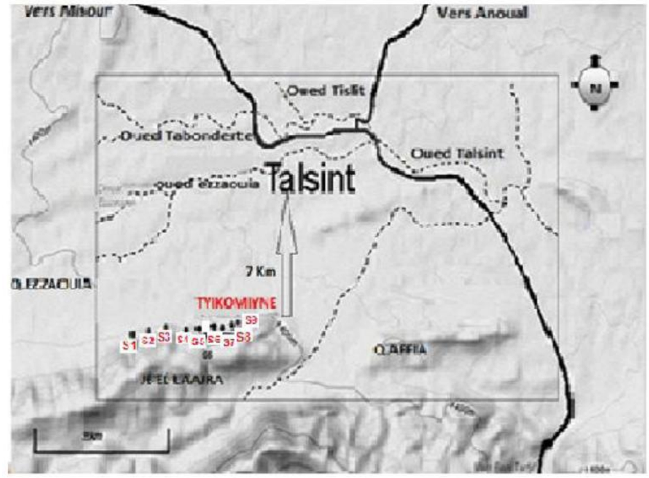

Figure 1 : Location of the studied sources (S1 to S9) which are named : Annakhla, Aghram, Almou, Albour, Akboub, Moulay abdallah1, Ouali oumousa, Moulay abdallah2, Ain l'oued

pre-Saharan bioclimate and Saharan environment. The temperature is high in the summer and very cold in winter, the average minimum of the coldest month (January) is -5 °C and the average maximum of the hottest month (July) is 47 °C. The average annual pluviometry was about 245 mm for the period 1983/2007 with large interannual gaps; it is about 500 mm for the period 2008/2010: the extremes recorded are 61 mm in 1998/1999 and 684.5 mm in 2009/2010[11].

Technical analysis

The sediments of the profound layer were collected using by a length corer of 1 m and 10 cm in diameter, buried in the sediment at a depth of 15 cm. These samples were introduced into plastic bags. Then, we made a brewing to obtain a homogeneous mixture. Once in the laboratory, sediment samples were dried in an oven for 24 hours and sieved to 0.2 mm over a series of sieves AFNOR. Then we took 1 g of sediment that mixed with 10 ml of HNO3 and 5 ml of $HClO_4$ at a temperature of 150 °C for 16 hours to have a good digestion[12]; and then was diluted digest obtained in 100 ml of distilled water for analysis.

Thus the concentrations of Fe, Mn, Zn, Cu, Pb, Cr, Co, Ni and Cd were analyzed using ICP-MS (Inductively Coupled Plasma Mass Spectrometry) in the laboratory of National Center Scientific and Technical Research (CNRST)-Morocco.

RESULTS AND DISCUSSION

Superficial sediments (SS) - profound sediments (SP)

In order to determine the average concentrations of heavy metals and to characterize the metal quality of sediments, nine sources have been identified on the card shown in Figure 1.

Our choice was focused on metals commonly found in surface sediments and profound sediments, namely: Lead, Cadmium, Copper, Nickel, Cobalt, Zinc, Iron, Chrome and Manganese. The results of analyzes of heavy metals in sediment samples collected and analyzed are shown in TABLE 1

Heavy metals

- Fer (Fe)

Figure 2 shows that the average concentrations are high in all sediment sources studied, and the maximum level may reach 36.97 mg/g in the profound sediment of SP9, while the lowest content obtained is 5.54 mg/g at SS5

Note that the iron concentration is widespread in all the studied sediments, the latter is probably related to the structure of silicates which are main components of sediments[13]. In addition, in eight out of nine measuring points, the average concentrations of Fe in the profound sediments are higher to those of surficial sediments. These results suggest that sediment deposition can accumulate more or less important and the old or older from the watershed Guir input is encouraged and dominant. Therefore the concentrations found in iron learn about the past more or less distant sediment state.

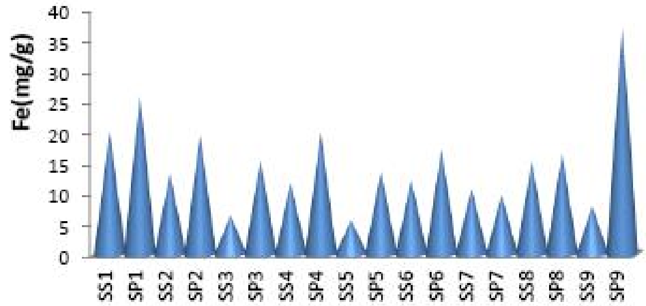

Figure 2 : Spatial variation of the iron average content of the Tyikomiyne sources sediment

In all study sites, the average iron content (15.34 mg/g) exceed that of non-polluted sediment (13.2 mg/g)[14]. Excess iron could come from regional geological

TABLE 1 : Average levels of heavy metals in superficial sediments (SS) and profound sediments (SP) of nine water sources in Tyikomiyne (µg/g)

	Mn	Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn
SS1	230	0,3	2,62	27,22	26,91	19920	17,94	3475,13	76,09
SP1	230	0,26	4,52	32,48	28,89	25830	18,37	1678,66	89,19
SS2	250	0,27	77,8	26,72	61,8	13190	62,07	451,39	276,43
SP2	270	0,29	4,72	28,18	19,62	19290	18,73	52,97	170,27
SS3	110	0,29	174,01	11,43	13,17	6330	11,29	24,9	21,42
SP3	140	0,25	2,95	22,88	33,04	15360	14,39	58,49	38,56
SS4	160	0,33	0,33	15,22	36,71	11610	12,18	36,88	62,43
SP4	290	0,29	2,51	22,65	27,09	19720	17,32	74,32	102,6
SS5	90	0,33	0,33	10,24	15,61	5540	9,73	12,75	24,51
SP5	340	0,34	6,3	33,42	35,29	13560	18,58	627,83	46,72
SS6	220	0,36	0,54	17,68	19,12	12150	16,05	40,59	37,34
SP6	410	0,31	8,02	39,33	45,39	17020	23,25	719,88	53,51
SS7	240	0,34	1,61	19,75	24,05	10680	20,27	49,3	42,77
SP7	220	0,31	2,63	16,9	18,79	9660	14,24	39,33	57,97
SS8	270	0,3	6,06	29,48	28,88	15040	21,21	74,17	51,15
SP8	260	0,3	3,41	29,19	19,66	16430	41,02	67,15	48,71
SS9	540	0,3	0,3	17,41	88,15	7840	30,55	139,79	54,39
SP9	160	0,3	9,41	96,32	47,01	36970	43,16	176,67	92,79
Average	246,11	0,3	17,11	27,58	32,73	15340	22,79	433,34	74,82

context (rich in ferromagnesian) as has been found by other authors for different sites of our[15], to highlight an old moderate pollution by iron.

Manganese (Mn*)*

Such as iron, in profound sediments, all sources have high concentrations of metallic element Mn compared to superficial sediments, except for source 9 which has a very high concentration at SS9 (540 µg/g) (Figure 3). These results suggest that in most of the sources studied, old sedimentary contribution coming from the

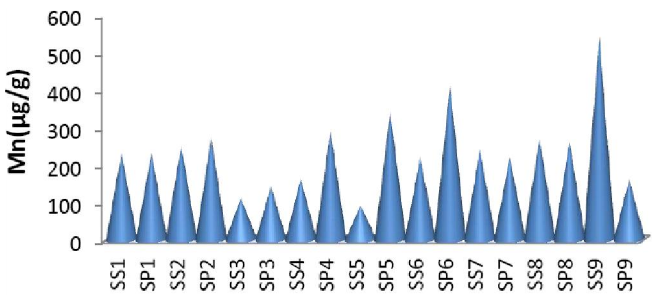

Figure 3 : Spatial variation of the average manganese content in sources sediments

watershed Guir input is encouraged and dominant.

The enrichment of manganese could be attributed to the regional geological context. Previous work[16] have shown that the origin of this element is both anthropic and natural.

Zinc (Zn)

The concentrations of this metal were between 21.42 and 276.43 µg/g with an average of 74.82 µg/g (Figure 4). In addition, a particularly high concentration were noted in the sediment surface of SS2, around 276.43 µg/g. Moreover, the important intake of the zinc in this particular level provides an information on the recent state of sediment. It should be mentioned that

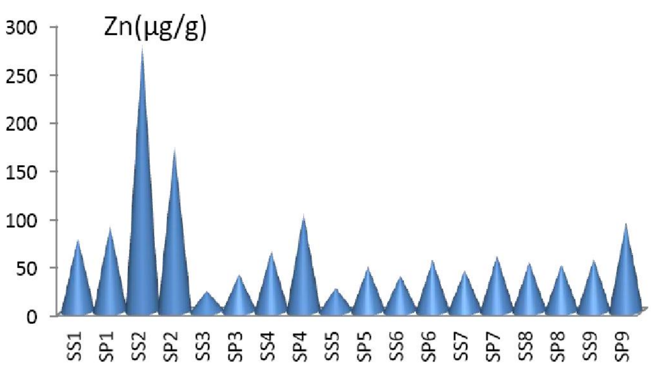

Figure 4 : Spatial variation of the average zinc content of Tyikomiyne sources sediment

the concentrations of the Zn determined in all stations by our analyzes generally remain lower relative to those found in SS2.

The results of analysis of metals in sediments studied show that the average content of Zn (74.82 µg/g) is lower than the reference level (90 µg/g)[17], and also below the reference value 200 µg/g fixed for the soil[18].

We underline thus a metal depollution of Zn in all measurement points. Therefore the metal Zn does not risk disturb the aquatic life of the community studied.

Copper (Cu)

Such as zinc, the found values of copper vary from according to the sources. The high copper content (88.15 µg/g) was obtained at the source 9, at the su-

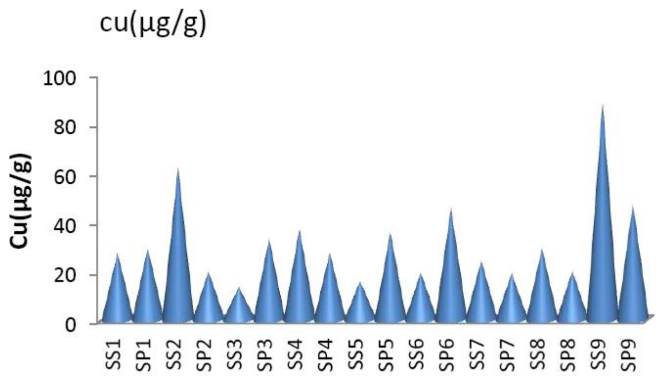

Figure 5 : Spatial variation of the average copper content of Tyikomiyne sources sediment.

perficial sediment rich in copper SS9 (Figure 5).

Thus the results of analysis of heavy metals in all studied sediments, show that for Cu, the average concentration (32.73 µg/g) is slightly higher than the level of reference[19] which is 30 µg/g. But, this value remains below the reference value of 50 µg/g fixed for the soil. Therefore the metallic element Cu is not likely to disturb the ecological balance of the environment studied.

- Chrome (Cr)

The concentrations obtained in chrome oscillate between 11.43 and 96.32 µg/g with a mean of 27.58 µg/g (Figure 6). Thus profound sediments deposited for most measuring points have high concentrations of Cr element that was derived from the superficial sediments.

Such as iron, the high concentration in Cr was obtained in the source 9 at SP9. These results suggest that this metalic element was transported in the source sedi-

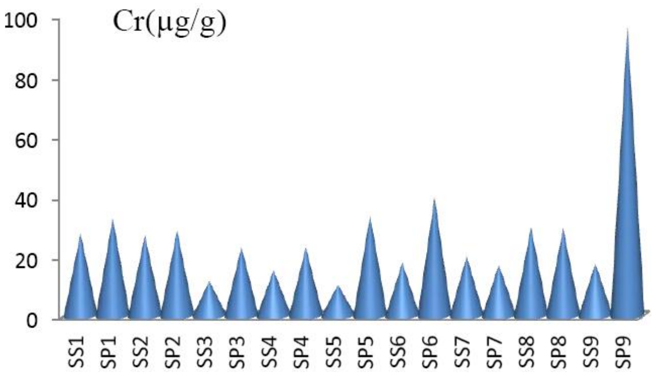

Figure 6 : Spatial variation of the average Cr content of Tyikomiyne sources sediment

ment from the old sedimentary deposits of Watershed Guir.

In all measurement points, the mean concentration of Cr (27.58 µg/g) at the studied sediments is less than the value of 75 µg/g indicative for soil[18]. Therefore the Cr metal element not disrupts aquatic life of the medium studied.

Cobalt (Co)

The concentrations of cobalt element varie between 0.3 and 174 µg/g (Figure 7), with a mean of 17.11 µg/g. So, these concentrations are generally very in sediments of the studied sources, except surficial sediments of SS2 (77.8 µg/g) and SS3 (174.01 µg/g) having slightly elevated concentrations. These results suggest that high intake of cobalt in

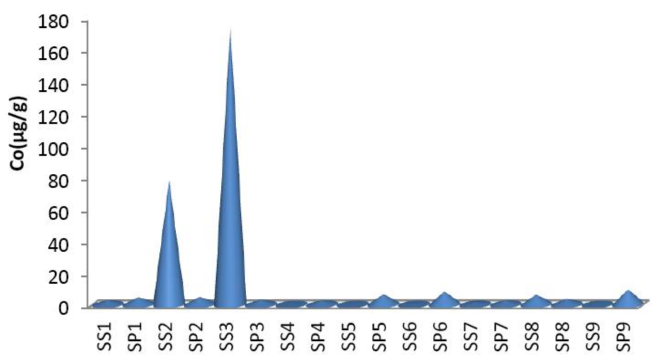

Figure 7 : Spatial variation of the average Co content of Tyikomiyne sources sediment

these particular levels provides information on the recent state of the sediment

In all measurement points, the mean concentration of Co (17.11 µg/g) at the studied sediments is less than the value of 25 µg/g, reference value for soil[18]. Therefore, the Co does not disrupt the aquatic life of the studied sources.

Plomb (Pb)

The analysis results show that lead levels oscillate between 12.75 and 3475.13 µg/g, with a mean of 176.67 µg/g (Figure 8). Note that sediment contamination by lead is widespread in several points. Thus, the

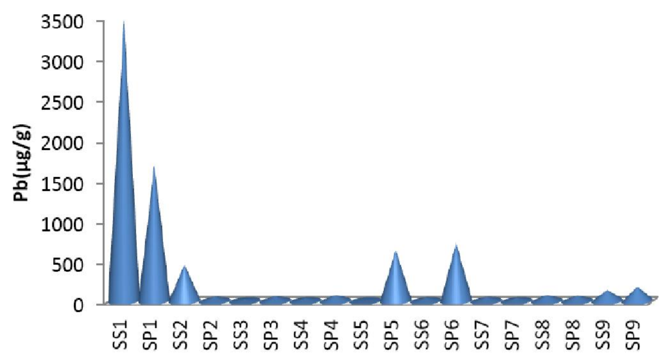

Figure 8 : Spatial variation of the average Pb content of Tyikomiyne sources sediment

concentration observed at the superficial sediment deposited SS1 was 3475.13 µg/g.

Thus, in all measurement points the mean concentration of Pb (433.34 µg/g) at the studied sediments are eight times the value of 50 µg/g, reference value for soil[18]. In addition, the enrichment of lead could be due to regional geological context. Therefore the metal element Pb may disrupt aquatic life of our study site.

Cadmium

In general, in all sources studied there is no significant difference between the concentrations of cadmium in superficial sediments and those sediments deposited profound. The mean concentration is obtained of the order 0.3 µg/g (Figure 9), below the value of 0.8 µg/g, reference value of the soil[18]. Consequently, the metal-

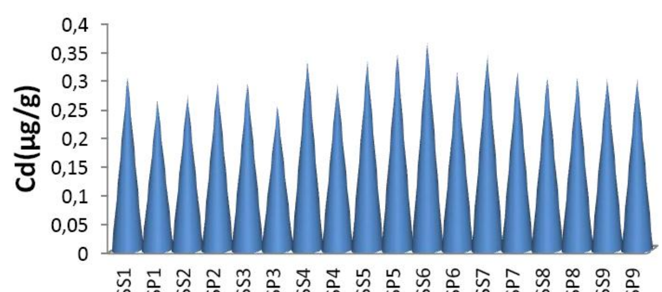

Figure 9 : Spatial variation of the average cadmium content of Tyikomiyne sources sediment

lic element cadmium does not risk disrupt aquatic life of our study site.

Nickel (Ni)

The nickel content in sediments studied are between 9.73 µg/g (SS5) and 62 µg/g (SS2) (Figure 10), with a mean of 22.79 µg/g. In several sources where a comparison is possible between the two types of sediment, we note that the concentrations of superficial sediments are lower than those of profound sediments. These results show that the sediment that accumulates in deposit more or less important is coming, in large part, from the contribution of the basin of the Guir. In addition, the comparison of the concentrations of the Ni in the superficial sédimentents and those found in th deep

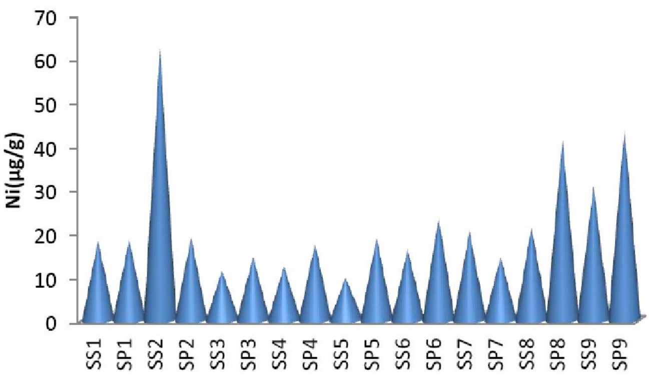

Figure 10 : Spatial variation of the average Ni content of the sediments

sediments gives information on the hitorique the mineral status of the sediment with respect to the metal.

On the other hand, the maximum concentration, which is about 62 µg/g, was observed in the deposited superficial sediment (SS2). This result supports the conclusion that an important contribution of Ni at this level particular provides information about the recent state of the sediment. Thus the mean concentration of Ni in sediments of the nine sources was 22.79 µg/g. It is less than the value of 50 µg/g which is the reference of the soil[18].

CONCLUSION

In most measurement points, the average concentrations of Fe, Mn, Ni and Cr in the deep sediments are higher than those of surface sediments. This result can be Explained by the phenomenon of migration down thesis metallic elements. Therefore the vertical evolution of the metallic element concentrations provides some history informations of the geological contitution of the sediment.

In several sources, metals: Zn, Cu, Cr, Co, Cd and Ni are unlikely to disturb the aquatic life in the study area. In contrast, the enrichment of metallic elements Fe, Mn and Pb in most measurement points, is creating a risk of harm to aquatic life in our study areas. In addition, the classification based on the average concentration of heavy metals in all studied sediments, generally gives: Fe> Pb> Mn> Zn> Cu> Cr> Ni> Co.

Therefore, these results clearly show the relatively polluted state of sediment in the study sites in many metallic elements, namely Fe, Mn and Pb, and therefore their likely impact on the quality of water sources in the area may threaten the health of users.

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