Bull Environ Contam Toxicol (2012) 89:495–500
DOI 10.1007/s00128-012-0738-0

# Metal Concentrations in the Water of Chah Nimeh Reservoirs in Zabol, Iran

**Ghasem Rajaei · Borhan Mansouri · Hamid Jahantigh · Amir Hossein Hamidian**

Received: 20 March 2012 / Accepted: 9 July 2012 / Published online: 19 July 2012


**Abstract** The main objectives of this article were to monitor the metal concentrations of Fe, Cu, Pb, B, Ni, V, Cd, Se, As, and Cr in the water of Chah nimeh reservoirs in Zabol, south-eastern Iran; and to identify any relationships between metals. Metal concentrations in the water samples were analyzed using ICP-OES. The results indicated that there were a highly positive correlation between Cr and Se, Ni ($p < 0.01$), and, between As and Ni ($p < 0.01$). Also, there were significant differences between Cr, Ni, Pb, and Se in the water of Chah nimeh reservoirs.

**Keywords** Pollution · Trace metal · Water quality · Chah nimeh reservoirs

Zabol is a city in and the capital of Zabol County in Sistan and Baluchestan Province, Iran. Zabol lies on the border with both Afghanistan and Pakistan. At 2006 census, its population was 130,642, consisting 27,867 families. Also, Zabol area is well known for its "120 day wind", a highly persistent dust storm in the summer which blows from north to south. It is situated at a latitude of 31° 01′ N and longitude of 60° 30′ E and about 1,350 m above sea level. The climate of the city is semi- arid and arid with cold winter and approximately 8 months dry season (from middle of April to December). Its average rainfall is 94 mm and unevenly distributed throughout the year. The average annual temperature is 22.7°C with the warmest month in July (average 35.2°C) and the coldest in January (average 8.9°C). The sunlight of the year is 263 days. Chah-Nimeh reservoirs of Zabol are three natural and big cavities in the south of Sistan Plain in south-eastern Iran and cover an area of 50 million square meters. The water stored in these cavities is used to irrigate the Sistan Plain and to provide the potable water of Zabol and Zahedan (Homayoun nezhad et al. 2007).

Surface water, as one of the purest forms of water available in nature, meets the overall demand of rural and semi-urban people. People in the south-eastern part of Iran with a semi-arid and arid climate and little rainfall, rely on aquifer systems for their freshwater needs. Sources of drinking water such as streams, rivers, lakes, dams, reservoirs and groundwater might be directly or indirectly polluted. Discharges of municipal and industrial wastewaters, containing organic pollutants, chemicals and metals, and run-off from land-based activities are the main sources of water pollution (Goldar and Banerjee 2004). Metal pollution of water bodies, because of their toxicity, bioaccumulation, long persistence, and biomagnification in the food chain, is a worldwide problem. Metals discharged from natural and anthropogenic sources are ubiquitous in the global environment (Gangaiya et al. 2001; Mansouri et al. 2011b). Metal concentrations in aquatic ecosystems are usually monitored by determination of their concentrations in water and sediment samples (Ebrahimpour

G. Rajaei (✉)
Young Researchers Club, Gorgan Branch,
Islamic Azad University, Gorgan, Iran
e-mail: Ghasem.rajaei19@yahoo.com

B. Mansouri
Young Researchers Club, Kermanshah Branch,
Islamic Azad University, Kermanshah, Iran
e-mail: borhanmansouri@yahoo.com

H. Jahantigh
Department of Geology, Zahedan Branch,
Islamic Azad University, Zahedan, Iran
e-mail: Hjahan9@gmail.com

A. H. Hamidian
Department of Environment, Faculty of Natural Resources,
University of Tehran, Karaj, Iran
e-mail: a.hamidian@ut.ac.ir

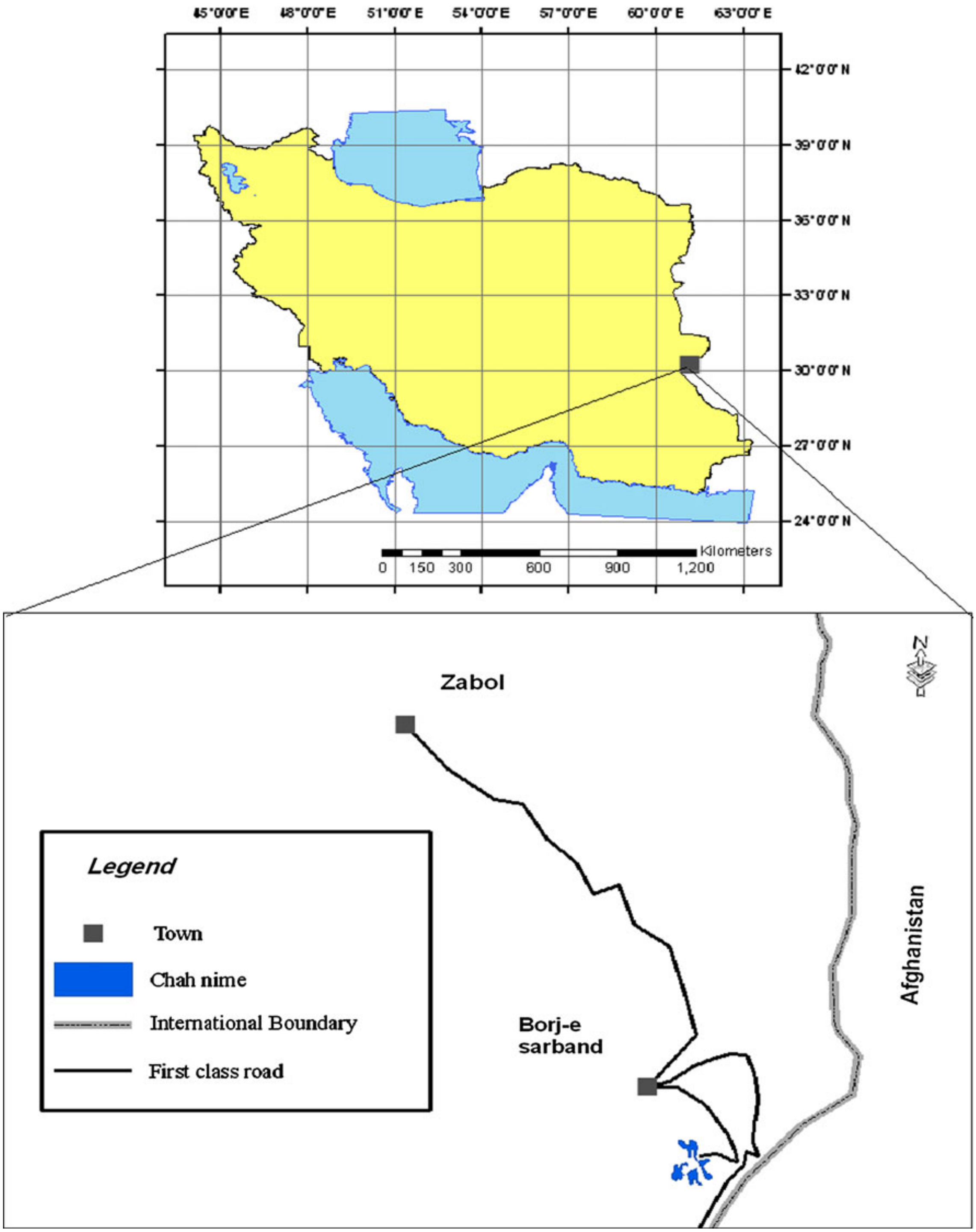


**Fig. 1** Location of Chah nimeh reservoirs of south-eastern Iran

and Mushrifah 2008). Metal pollution in water bodies is generally one of the main types of pollution that may stress the biotic community (Baldantoni et al. 2004). Furthermore, water pollution causes not only the degradation of water quality but also threatens human health and the balance of aquatic ecosystems, economic development and social prosperity (Milovanovic 2007). Considering the effects of human activities on water quality and the problems caused by water pollution, it is of high necessity to monitor the quality of water resources (Mansouri et al. 2011a). The assessment of water quality can be the first and perhaps the most important step toward applying an appropriate quality management plan in order to reduce or preferably eliminate water pollution (Sanchez et al. 2007).

Our study aimed at further investigation of the concentrations of Fe, Cu, Pb, B, Ni, V, Cd, Se, As, and Cr in the water of Chah nimeh reservoirs in Zabol, south-eastern Iran in order to: (1) compare metal concentrations between three Chah nimeh reservoirs, (2) identify any relationships between metals, and (3) compare metal concentrations with standard values recommended by WHO.

## Materials and Methods

Water samples were collected from 16 sites in three different Chah nimeh reservoirs in the Zabol in the April to June 2010 (Fig. 1). Water samples were collected into acid washed 250-ml plastic bottles. The samples were kept in refrigerator maintained at 4°C. The water samples were filtered using a 0.45 µm nitrocellulose membrane filter. Prior to any analysis, all equipment and containers were soaked in 10 % $HNO_3$ and rinsed thoroughly with deionized distilled water before use. The concentrations of metals were estimated using ICP-OES. Percent recoveries of samples were above 90 % in most cases.

Statistical analyses were carried out using SPSS ver. 16.0. Data were tested for normality using a Kolmogorov–Smirnov test. Metal concentration in water was tested for mean differences between Chah nimeh reservoirs using One-way ANOVA. A Pearson correlation (r) was used to test correlations. The level of significance was set at $\alpha = 0.05$. All concentrations are reported in µg $L^{-1}$. Values are given in means ± standard deviations (SD).

## Results and Discussion

The mean concentration of the metals in the surface water of the Chah nimeh reservoirs is given in Tables 1, 2 and 3. In this study, the ten metals concentrations in surface water of Chah nimeh reservoirs 1, 2, and 3 were decreased in the sequence: Fe>Cr>B>Pb>Ni>Cu>Cd>As>Se>V; Fe>B>Cu>Cr>Pb>Ni>Cd>As>V>Se; and Fe>B>Cu>Cr>Cd>

**Table 1** Levels of metal concentrations (µg $L^{-1}$) in water samples in Chah nimeh reservoirs 1

| Station | Metals | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | As | B | Cd | Cr | Cu | Fe | Ni | Pb | Se | V |
| 1 | 17 | 94.6 | 11.8 | 54.4 | 23.9 | 123.1 | 25.2 | 48.4 | 6.6 | 3.4 |
| 2 | 1.8 | 43.5 | 4.7 | 49.7 | 5.4 | 164.6 | 13.3 | 52.7 | 4.3 | 1.3 |
| 3 | 4.9 | 34.1 | 17.7 | 80.3 | 17.1 | 342.7 | 17.6 | 11.2 | 13.2 | 2.4 |
| 4 | 6.8 | 120.8 | 2.7 | 39.3 | 24.0 | 291.0 | 29.2 | 17.4 | 7.7 | 0.3 |
| 5 | 3.6 | 88.8 | 25.2 | 87.1 | 55.7 | 422.2 | 22.1 | 30.8 | 11.2 | 4.6 |
| 6 | 12.4 | 28.1 | 3.7 | 59.6 | 0.4 | 469.6 | 19.3 | 29.8 | 17.0 | 13.1 |
| 7 | 20.2 | 17.5 | 8.5 | 66.3 | 31.1 | 371.5 | 36.2 | 13.5 | 3.8 | 0.5 |
| Min | 0.7 | 15.9 | 1.9 | 35.3 | 0.0 | 114.7 | 11.9 | 9.9 | 3.0 | 0.0 |
| Max | 22.4 | 125.3 | 29.9 | 92.1 | 59.2 | 476.3 | 39.1 | 57.7 | 17.9 | 15.2 |
| Mean | 9.5 | 61.1 | 10.6 | 62.4 | 22.5 | 312.1 | 23.3 | 29.1 | 9.1 | 3.7 |
| SD | 7.2 | 40.1 | 8.3 | 17.2 | 18.2 | 128.6 | 7.8 | 16.6 | 4.9 | 4.4 |
| WHO 2003 | 10 | 300 | 3.0 | 50 | 2,000 | 300 | 70 | 10 | – | – |

**Table 2** Levels of metal concentrations (µg $L^{-1}$) in water samples in Chah nimeh reservoirs 2

| Station | Metals | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | As | B | Cd | Cr | Cu | Fe | Ni | Pb | Se | V |
| 1 | 4.7 | 36.9 | 2.3 | 3.6 | 26.7 | 411.3 | 7.9 | 24.4 | 1.7 | 2.6 |
| 2 | 11.6 | 25.1 | 3.4 | 36.8 | 85.7 | 184.4 | 15.4 | 13.1 | 2.9 | 9.2 |
| 3 | 6.7 | 46.5 | 9.6 | 12.8 | 40.3 | 525.2 | 3.5 | 5.6 | 6.5 | 1.2 |
| 4 | 5.4 | 100.0 | 11.7 | 24.4 | 63.0 | 228.7 | 5.4 | 19.5 | 1.8 | 5.8 |
| 5 | 3.6 | 61.5 | 16.6 | 17.8 | 19.9 | 342.4 | 11.6 | 8.3 | 4.6 | 0.3 |
| Min | 3.0 | 22.3 | 1.7 | 3.1 | 18.1 | 177.2 | 3.1 | 4.7 | 1.2 | 0.0 |
| Max | 13.2 | 109.1 | 19.1 | 42.7 | 92.8 | 539.1 | 17.7 | 26.9 | 7.1 | 10.3 |
| Mean | 6.4 | 54.0 | 8.7 | 19.1 | 47.1 | 338.4 | 8.8 | 14.2 | 3.5 | 3.8 |
| SD | 3.2 | 29 | 6.2 | 12.7 | 27.2 | 138.0 | 4.8 | 7.9 | 2.1 | 3.7 |
| WHO 2003 | 10 | 300 | 3.0 | 50 | 2,000 | 300 | 70 | 10 | – | – |

**Table 3** Levels of metal concentrations (μg $L^{-1}$) in water samples in Chah nimeh reservoirs 3

| Station | Metals | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | As | B | Cd | Cr | Cu | Fe | Ni | Pb | Se | V |
| 1 | 1.7 | 96.7 | 1.9 | 26.6 | 19.1 | 392.7 | 3.0 | 13.3 | 1.5 | 3.7 |
| 2 | 4.4 | 58.8 | 6.4 | 23.8 | 61.5 | 101.9 | 5.7 | 5.9 | 2.3 | 2.5 |
| 3 | 2.8 | 78.8 | 9.7 | 8.2 | 77.3 | 365.9 | 7.8 | 7.8 | 2.0 | 1.7 |
| 4 | 0.5 | 9.4 | 3.9 | 30.5 | 27.3 | 175.5 | 1.3 | 14.6 | 4.1 | 2.1 |
| Min | 0.4 | 8.1 | 1.5 | 7.8 | 17.6 | 94.8 | 1.0 | 4.4 | 1.0 | 1.0 |
| Max | 4.7 | 104.6 | 10.4 | 33.2 | 82.2 | 405.5 | 8.3 | 16.8 | 4.7 | 4.0 |
| Mean | 2.4 | 60.9 | 5.5 | 22.3 | 46.3 | 259.0 | 4.5 | 10.4 | 2.5 | 2.5 |
| SD | 1.7 | 37.9 | 3.4 | 9.8 | 27.8 | 142.6 | 2.9 | 4.4 | 1.1 | 0.8 |
| WHO 2003 | 10 | 300 | 3.0 | 50 | 2,000 | 300 | 70 | 10 | – | – |

**Table 4** The analysis of variance (ANOVA) of the data at different Chah nimeh reservoirs

| Parameter | *F* | *p* |
|---|---|---|
| As | 2.46 | NS |
| B | 0.06 | NS |
| Cd | 0.74 | NS |
| Cr | 17.18 | $p < 0.001$ |
| Cu | 2.08 | NS |
| Fe | 0.39 | NS |
| Ni | 15.21 | $p < 0.001$ |
| Pb | 3.81 | $p < 0.05$ |
| Se | 5.86 | $p < 0.01$ |
| V | 0.17 | NS |

*p* significance level, *NS* not significant

Pb>Ni>As>V>Se, respectively. Statistical analyses were also carried out to establish the differences among three of Chah nimeh reservoirs. There were significant differences between metals of Cr, Ni, Pb, and Se (Table 4) in water of Chah nimeh reservoirs.

Cadmium and lead are very toxic and common pollutants in the environment. Exposing to these metals for a long period can result to damages in kidney, liver, circulatory system, and nerve tissue (Mansouri et al. 2012). Death or permanent damage to the central nervous system, the brain, and kidneys due to exposure to high concentrations of lead are also reported (Hanaa et al. 2000). According to the results and findings of the study, the Cd and Pb concentrations is found to be high in most of the samples as they exceeded the WHO guideline value of 3.0 and 10.0 μg $L^{-1}$, respectively. Compared to the reported data from other parts of Iran, the Pb and Cd concentrations in the surface water of Chah nimeh reservoirs were high.

The highest concentrations of iron were observed in the water samples, which resulted changes in its color and taste (Chung et al. 2009). High concentrations of iron can cause serious health problems or premature death such as damaging liver, heart, and endocrine glands, and result in debilitating and life-threatening problems (Nduka and Orisakwe 2011). Iron concentrations less than 500 μg $L^{-1}$ are reported for groundwater samples (Oyeku and Eludoyin 2010). Haloi and Sarma (2011) reported relatively high iron concentrations and above the permissible level in Assam's drinking water.

Arsenic has the potential to circulate in various forms through the atmosphere, water and soil. Sufficient epidemiologic evidences (Saha and Zaman 2011) exist for the classification of arsenic as a 'human carcinogen' element.

**Table 5** Correlation coefficient (*r*) between the metal concentrations in water samples from Chah nimeh reservoirs

| Element | As | B | Cd | Cr | Cu | Fe | Ni | Pb | Se | V |
|---|---|---|---|---|---|---|---|---|---|---|
| AS | 1 | | | | | | | | | |
| B | −0.19 | 1 | | | | | | | | |
| Cd | −0.04 | 0.39 | 1 | | | | | | | |
| Cr | 0.36 | 0.17 | 0.47 | 1 | | | | | | |
| Cu | −0.03 | 0.16 | 0.16 | −0.26 | 1 | | | | | |
| Fe | −0.03 | −0.03 | 0.02 | −0.15 | −0.21 | 1 | | | | |
| Ni | 0.72* | 0.22 | 0.20 | 0.69* | −0.21 | −0.04 | 1 | | | |
| Pb | 0.17 | 0.16 | 0.01 | 0.40 | −0.41 | 0.16 | 0.32 | 1 | | |
| Se | 0.17 | 0.08 | 0.34 | 0.68* | −0.43 | 0.21 | 0.39 | 0.22 | 1 | |
| V | 0.27 | −0.14 | −0.15 | 0.22 | 0.07 | 0.05 | 0.01 | 0.18 | 0.44 | 1 |

* Correlation is significant at the $p < 0.01$

The highest and least levels of As and B were found to be 22.4 and 125.3 μg $L^{-1}$, and 0.4 and 8.1 μg $L^{-1}$. The levels fall below the WHO standard for drinking water. The mean concentration of As determined in this study ranged from 2.4 to 9.5 μg $L^{-1}$. These values were slightly lower than Nwankwoala et al. (2011) (10.0 μg $L^{-1}$) but very similar to those reported by Rios-Aranaa et al. (2003).

Selenium ranges from <0.1 to 100 μg $L^{-1}$ in aquatic ecosystem as one of minor elements, but rarely more than maximum contaminant level of 10 μg $L^{-1}$ in Environmental Quality Standard for drinking water (Ham et al. 2007). The results of this study showed that the mean concentration of Se in water of Chah nimeh reservoirs was lower than maximum contaminant level of 10 μg $L^{-1}$ in environmental quality standard for drinking water. Vanadium contents varied between 2.5 and 3.8 μg $L^{-1}$. These values were very similar to those reported by Nassef et al. (2006). The WHO had no recommended data concerning V concentration in water as shown in Table 1. The authors of FWQP reference sheet 11.2 found the concentration of V in the studied ground water was in the range from 0.1 to 100 μg $L^{-1}$ (FWQP reference sheet 11.2). It was indicated that V was naturally occurring metal in all the analyzed samples.

The ideal intake of Cu without any accumulative danger to the human body is 2 mg/day. Acute Cu poisoning will stimulate the alimentary canal and causes vomiting and pain (Chung et al. 2009). The concentration of Cu in water of the study area ranges from 22.5 to 47.1 μg $L^{-}1$, which is within the permissible limit of WHO. The natural content of Cr in drinking water is very low ranging from 10 to 50 μg $L^{-1}$ except from the regions with substantial chromium deposits (Jayana et al. 2009). Chromate dust is carcinogenic and high concentrations of Cr cause liver and kidney damage and (Mugica et al. 2002). High concentrations of Cr can be toxic especially in the hexavalent form. The WHO (2003) recommends a concentration of 70 μg $L^{-1}$ MAL for Ni in drinking water. The concentrations of Ni found in this study range from 23.3 to 4.5 μg $L^{-1}$.

In order to make a quantitative analysis of the relationship among trace element contents in surface water samples, Pearson's correlation analysis was applied to the data (Table 5). There was a highly positive correlation between Cr and Se, Ni ($p < 0.01$), and, between As and Ni ($p < 0.01$). Studies on the metals on the groundwater of Multan, Pakistan, Tariq et al. (2010) showed that the positive correlation was between Cr and Ni (r = 0.69), thus manifesting the simultaneous excess of these trace metals. We hypothesize that metals with a high positive correlation might have been originated from the same pollution source.

Water source is one of the most important limiting factors in the arid and semi- arid regions. In this study, Pearson correlation showed that there was significant correlation among Cr, Se, Ni and As metals ($p < 0.01$). Indeed, the levels of metals in the water of Chah nimeh reservoirs did not exceed the permissible limits specified by the WHO guideline values for drinking water. However, the concentration of Cd and Pb in water was higher than the WHO guidelines.

## References


Baldantoni D, Alfani A, Tommasi PD (2004) Assessment of macro and microelement accumulation capability of two aquatic plants. Environ Pollut 130:149–156

Chung PL, Chung CY, Liao SW, Miaw CL (2009) Assessment of the school drinking water supply and the water quality in Pingtung County, Taiwan. Environ Monit Assess 159:207–216

Ebrahimpour M, Mushrifah I (2008) Heavy metal concentrations in water and sediments in Tasik Chini, a freshwater lake, Malaysia. Environ Monit Assess 141:297–307

FWQP reference sheet 11.2 (2003).http://www.anrcatalog.ucdavis.edu/pdf/8084.pdf

Gangaiya P, Tabudravu J, South R, Sotheeswaran S (2001) Heavy metal contamination of the Lami coastal environment, Fiji. S Pac J Nat Sci 19:24–29

Goldar B, Banerjee N (2004) Impact of informal regulation of pollution on water quality in rivers in India. J Environ Manag 73:117–130

Haloi N, Sarma HP (2011) Heavy metal contaminations in the groundwater of Brahmaputra flood plain: an assessment of water quality in Barpeta District, Assam (India). Environ Monit Assess. doi:10.1007/s10661-011-2415-x

Ham YS, Tamiya S, Choi IS (2007) Estimation of selenium concentration in shallow groundwater in alluvial fan area in Tsukui, central Japan. Environ Monit Assess 125:85–90

Hanaa M, Eweida A, Farag A (2000) Heavy metals in drinking water and their environmental impact on human health. In: International conference on environmental hazards mitigation, Cairo University, Egypt, pp 542–556

Homayoun nezhad I, Savari A, Saeidpour B, Nouri GHR (2007) Investigation of water quality: a case study of Zabol Chah nimeh reservoirs. J Environ Sci Technol 9:13–21

Jayana BL, Prasai T, Singh A, Yami KD (2009) Assessment of drinking water quality of madhyapur-thimi and study of antibiotic sensitivity against bacterial isolates. Nepal J Sci Technol 10:167–172

Mansouri B, Baramaki R, Ebrahimpour M (2011a) Acute toxicity bioassay of mercury and silver on *Capoeta fusca* (black fish). Toxicol Ind Health 28:393–398

Mansouri B, Ravangard E, Rezaaei Z, Mansouri A (2011b) Determining the concentration parameters of quality of drinking water; a case study in Birjand. Iran Inter J Curr Res rev 9:33–36

Mansouri B, Salehi J, Etebari B, Kardan Moghaddam H (2012) Metal concentrations in the groundwater in Birjand flood plain. Iran Bull Environ Contam Toxicol 89:138–142

Milovanovic M (2007) Water quality assessment and determination of pollution sources along the Axios/Vardar River, Southeastern Europe. Desalination 213:159–173

Mugica V, Maubert M, Torres M, Munoz J, Rico E (2002) Temporal and spatial Variations of metal content in TSP and $PM_{10}$ in Mexico City during 1996–1998. J Aero Sci 33:91–102

Nassef M, Hannigan R, EL Sayed KA, El. Tahawy MS (2006) Determination of some heavy metals in the environment of Sadat industrial city. In: Proceedings of the 2nd environmental physics conference, 18–22 Feb 2006, Alexandria, Egypt, pp 145–152

Nduka JK, Orisakwe OE (2011) Water-quality issues in the Niger Delta of Nigeria: a look at heavy metal levels and some physicochemical properties. Environ Sci Pollut Res 18(2):237–246

Nwankwoala HO, Udom GJ, Ugwu SA (2011) Some Heavy metal Investigations in groundwater sources in Yenagoa, Bayelsa State, Nigeria. J Appl Technol Environ Sanit 1:163–170

Oyeku OT, Eludoyin AO (2010) Heavy metal contamination of ground water resources in a Nigerian urban settlement. Afr J Environ Sci Technol 4:201–214

Rios-Aranaa JV, Walsh EJ, Gardea-Torresdey JL (2003) Assessment of arsenic and heavy metal concentrations in water and sediments of the Rio Grande at El Paso–Juarez metroplex region. Environ Inter 29:957–971

Saha N, Zaman MR (2011) Concentration of selected toxic metals in groundwater and some cereals grown in Shibganj area of Chapai Nawabganj, Rajshahi, Bangladesh. Curr Sci 101:427–431

Sanchez E, Colmenarejo MF, Vicente J, Rubio A, Garcia MG, Travieso L, Borja R (2007) Use of the water quality index and dissolved oxygen deficit as simple indicators of watersheds pollution. Ecol Indic 7:315–328

Tariq SR, Shaheen N, Khalique A, Shah MH (2010) Distribution, correlation, and source apportionment of selected metals in tannery effluents, related soils, and groundwater—a case study from Multan, Pakistan. Environ Monit Assess 166:303–312

WHO (World Health Organization) (2003) Guidelines for drinking water quality. Background document for preparation of WHO guidelines for drinking water quality. Geneva, World Health Organization. (WHO/SDE/WSH/03.04/4)