

Water Quality and Some Heavy Metals in Water and Sediments of Euphrates River, Iraq

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Abstract: Water samples, sediments from three stations in Euphrates River, Iraq were analyzed quantitatively for some physical and chemical characters and six heavy metals (Co, Cu, Fe, Mn, Ni and Pb) using flam atomic absorption spectrophotometer in period Sept. 2009-Oct. 2010. The physical and chemical characters included temperature, pH, water flow, salinity, dissolved oxygen, BOD₅, alkalinity total hardness, calcium and nutrients (nitrite, nitrate reactive phosphate and silicate). The results showed variation in water flow 0.05-0.40 m/sec., according to the values of salinity 0.40%-0.60% values of the BOD₅ were ranged between 0.2-4.3 mg/L. The mean concentration of the heavy metals (Pb, Ni, Mn, Co, Cu and Fe) of the dissolved phase in water were 0.13 µg/L, 0.021 µg/L, 0.31 µg/L, 4.29 µg/L, 7.78 µg/L, 6.46 µg/L and 79.04 µg/L, respectively, while their concentration in the particulate phase were 0.59 µg/g, 0.06 µg/g, 0.42 µg/g, 50.06 µg/g, 6.61 µg/g, 7.17 µg/g and 149.42 µg/g dry weight, respectively. Also the mean concentrations of heavy metals in sediment (exchangeable phase) were 0.51 µg/g, 0.18 µg/g, 0.08 µg/g, 61.39 µg/g, 5.40 µg/g, 14.06 µg/g and 130.05 µg/g dry weight respectively, and 0.40 µg/g, 0.17 µg/g, 0.10 µg/g, 63.01 µg/g, 4.64 µg/g, 18.44 µg/g and 126.26 µg/g D.W. respectively in residual phase of sediment.

Key words: Heavy metals, water quality, environmental pollution, sediment, Euphrates River.

1. Introduction

Heavy metals are among the most common environmental pollution, and their occurrence in water and biota indicate the presence of natural or anthropogenic source [1]. Heavy metals in aquatic system have many origin; distribution and accumulation of metals are influenced by mineralogical composition, sediment texture, adsorption, desorption processes and oxidation-reduction state and physical transport [2]. Heavy metals can effect the ecosystems through bioaccumulation and biomagnifications process and are potentially toxic for environment and human life [3]. The behavior of metals in natural water is a function of the substrate sediment composition, the

suspended sediment composition, and the water chemistry. During their transport, the heavy metals undergo numerous change in the speciation due to dissolution, precipitation, sorption and complexation phenomena [4].

The geochemical composition of water body is largely governed by the physicochemical characteristics (pH, EC, DO, etc.), of the deposition environment and associated natural biogeochemical processes such as diagenesis, adsorption/desorption on/of organic matter and precipitation-dissolution of Fe-Mn oxyhydroxides [5]. Sediment samples have also been widely used to monitor heavy metal pollution in marine and river system, and heavy metal contamination could frequently be identified through analysis [6].

Various studies have demonstrated that aquatic system are contaminated by heavy metals in different areas of world [7-15].

The purpose of this paper is to determine the

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physico-chemical properties and heavy metal in water and sediment of Euphrates River in middle of Iraq, with an aim to provide additional data and investigate the present level of metal in the area.

2. Materials and Methods

The present investigation area (180 km) was chosen along Euphrates River, middle of Iraq. It passes through three stations (Al-Hindia barrage, Al-Hindia and Al-Kafel).

Water and sediment samples were collected from three sites of the Euphrates River in period from October 2009 to September 2010. Each sampling sites were visited monthly, triplicate sample was collected from every point at each time. Field data like temperature, pH, EC (electrical conductivity), dissolved oxygen, water flow were measured in forenoon. Air and surface water temperature were measured using thermometer. pH and EC were measured using pH and EC meter model (HANNA). Dissolved oxygen was estimated by the modified Winkler's method [16]. For the analysis of water quality and nutrients, surface water samples were collected in clear polyethylene bottles and kept in an ice box and transported immediately to the laboratory. BOD₅, total hardness, calcium, magnesium, alkalinity were measured according to Lind et al. [17]. Nutrients (nitrite, nitrate, reactive phosphate and silicate) determined according to Parson et al. [18].

The filtered water samples were pre-concentrated with ion exchange type (chlex 100) extraction procedure as described by Riley et al. [19], and aspirated to a flame atomic absorption spectrophotometer (Pye Uni Cam SP9). Heavy metals in particulate phase extraction according to Sturgeon et al. [20]. Sediment samples were collected by Grab sampler and transferred to clean polyethylene bags, The samples were stored frozen until analysis heavy metals in exchangeable and residual phases of sediment was measured by digested with HNO₃:H₂SO₄:HClO₄:HF according to Sturgeon et al. [20].

3. Results and Discussion

The physical and chemical characters of water are considered as the important principles in the identification of the quality and type of the water for any aquatic system [21]. The result of measured physico-chemical parameters are presented in Table 1. Water temperature varied from 11-39 °C, 10-39 °C and 13-37 °C, respectively, at the three stations, Temperature is a factor of importance for aquatic ecosystem, as it affects the organisms as well as the physical and chemical characteristics of water [22].

The pH ranged between 7.4-8.5 (st. 1), 7.3-8.2 (st. 2) and 7.2-8.7 (st. 3). Generally, its seasonal variation in pH value due to many factors such as removal of (CO₂) by photosynthesis through bicarbonate degradation, low primary productivity, reduction of salinity and temperature and decomposition of organic matter [23].

Salinity values varied from 0.41‰-0.52‰ (st. 1), 0.40‰-0.55‰ (st. 2) and 0.42‰-0.60‰ (st. 3). The water of river in study sites was classified as oligosaline. The recorded high values from salinity could be attributed to the low amount of rain fall, higher rate of evaporation [24, 25].

Dissolved oxygen levels varied between 4.8 mg/L and 10.9 mg/L, 5 mg/L and 9.2 mg/L, and 5.3 mg/L and 11.8 mg/L, respectively in the three study sites. The higher value of DO which might due to the cumulative effect of higher wind velocity coupled with heavy rain fall and the resultant fresh water mixing [26, 27], but the low level of dissolved oxygen recorded can be attributed to low density of aquatic plants and phytoplankton [5], or the sewage discharges from the catchment area are gradually affecting the aquatic life [22]. The result showed low levels of BOD₅, ranged between 0.2 mg/L-4.3 mg/L. This was accepted by world limitations in all stations [28], may be due to the activity of microorganism and self purification in surface water systems [29].

The level of total alkalinity and total hardness for good fish culture were within 20 mg/L and 300 mg/L [30]. The present study showed that the results were

fell outside this range. The range of 131-159 mg CaCO₃/L (st. 1), 136-192 mg CaCO₃/L (st. 2) and 137-185 mg CaCO₃/L (st. 3) for total alkalinity and 516-600 mg CaCO₃/L (st.1), 469-656 mg CaCO₃/L (st. 2) and 518-664 mg CaCO₃/L (st. 3) for total hardness were what was recorded for the study. The result recorded values of calcium was ranged 123-290 mg CaCO₃/L (st. 1), 136.5-276 mg CaCO₃/L (st. 2) and 139.4-263 mg CaCO₃/L (st. 3). While magnesium concentration was ranged 70.2-112.5 mg CaCO₃/L (st.1), 68.07-124.3 mg CaCO₃/L (st. 2) and 62.9-127.3 mg CaCO₃/L (st. 3).

The concentration levels of nutrients in the water samples were showed in Table 1. Nitrates and nitrites are veritable indication of the biological pollution in natural water [22]. The highest nitrate value could be mainly due to the organic materials received from the catchment area [31] or through oxidation of ammonia form of nitrogen to nitrite formation [26].

The values of nitrite were ranged 0.46-1.96 µg/L (st. 1), 0.48-2.53 µg/L (st. 2) and 0.51-3.54 µg/L (st. 3), while nitrate were ranged 6.21-64.07 µg/L (st. 1), 5.83-66.3 µg/L (st. 2) and 7.36-61.9 µg/L (st. 3), and its results were showed no significant variation between sites but there are significant between different months. Nitrite and nitrate concentrations were depended on the serial microbial transformation which also depends on dissolved oxygen values [23].

The result recorded higher values of nitrite during some study seasons could be due to the increase phytoplankton excretion, oxidation of ammonia, reduction of nitrate and bacterial decomposition of planktonic detritus [25, 32, 33], but the low level of nitrite during summer may be due to the increase of salinity present [6].

Phosphorous is a limiting nutrient for algal growth and therefore controls the primary productivity of a water body [34]. This study recorded higher concentration of reactive phosphate in all study sites

Table 1 Physico-chemical characteristics of water in Euphrates River.

| Sites measurements | S1 | S2 | S3 |
|--|---------------------------------|--------------------------------|--------------------------------|
| Water temperature (°C) | 10.5-36 22.5 (±10.48) | 12-36 24 (±9.32) | 13-37 25 (±8.84) |
| pH | 7.4-8.5 7.8 (±0.33) | 7.3-8.2 7.7 (±0.25) | 7.2-8.7 7.9 (±0.41) |
| Salinity (‰) | 0.41-0.52 0.46 (±0.02) | 0.40-0.55 0.46 (±0.04) | 0.42-0.60 0.47 (±0.05) |
| Dissolved oxygen (mg/L) | 4.8-10.9 7.04 (±1.58) | 5 – 9.2 6.92 (±1.20) | 5.3-11.8 6.94 (±1.72) |
| BOD ₅ (mg/L) | 0.4-3.6 1.58 (±0.98) | 0.2-4.3 1.72 (±1.37) | 0.2-3.2 1.44 (±0.95) |
| Total Alkalinity (mg CaCO ₃ /L) | 131-159 160.12 (±17.60) | 136-192 162.12 (±17.04) | 137-185 164.80 (±14.85) |
| Total hardness (mg CaCO ₃ /L) | 516-600 556.7 (±30.54) | 469-656 547.5 (±46.97) | 518-664 556.08 (±39.22) |
| Calcium (mg CaCO ₃ /L) | 123-290 187.6 (±53.4) | 136.5-276 184.1 (±48.1) | 139.4-263 189.7 (±45.5) |
| Magnesium (mg CaCO ₃ /L) | 70.2-112.5 89.67 (±10.90) | 68.07-124.3 88.17 (±15.89) | 62.9-127.3 89.13 (±17.24) |
| Nitrite (µg/L) | 0.46-1.96 1.09 (±0.48) | 0.48-2.53 1.03 (±0.62) | 0.51-3.54 1.38 (±0.91) |
| Nitrates (µg/L) | 6.21-64.07 30.19 (±22.42) | 5.83-66.3 27.90 (±22.79) | 7.36-61.9 29.80 (±20.73) |
| Active phosphates (µg/L) | 0.77-6.03 3.37 (±1.60) | 0.72-7.16 3.03 (±1.80) | 0.80-5.70 3.11 (±1.29) |
| Sulphates (mg/L) | 19.84-333.05 118.80 (±98.50) | 21.25-323.6 119.64 (±96.50) | 21.09-340.6 119.56 (±99.44) |
| Active silicates (mg/L) | 143-4120 1,688.6 (±1412.3) | 174-4,080 1,481 (±1309.1) | 156-4,120 1,478 (±139,504) |

First line = mean, second line = average (±SD).

ranged 0.77-6.03 $\mu\text{g/L}$ (st. 1), 0.72-7.16 $\mu\text{g/L}$ (st. 2) and 0.80-5.70 $\mu\text{g/L}$ (st. 3). The higher concentration was maybe due to the input resulted from city sewage discharge, land drainage and urban run-off [13].

Sulphate is common form of sulfur in fresh water systems [28]. High levels of sulphate recorded in Euphrates River in all study sites were ranged 19.84-333.05 mg/L (st. 1), 21.25-323.6 mg/L (st. 2) and 21.09-340.6 mg/L (st. 3).

The silicate values were ranged 143-4,120 $\mu\text{g/L}$ (st. 1), 174-4,080 $\mu\text{g/L}$ (st. 2) and 156-4,120 $\mu\text{g/L}$ (st. 3). The silicate content was higher than that of the other nutrients could be due to large influx of fresh water derived from land drainage carrying silicate leached out from rocks and also from the bottom sediment [35], but the slightly decreased in silicate concentrations could be attributed to uptake of silicates by phytoplankton for their biological activity [6].

Results of heavy metals analysis in Euphrates River water and sediments are presented in Figs. 1, 2, which indicate that there are no significant differences between three selected sites in all seasons. Dissolved heavy metal in this study ranged between the lowest limit for Pb (0.012 $\mu\text{g/L}$) in winter 2010 and the highest limited for Fe (125.12 $\mu\text{g/L}$) in spring 2010. While the particulate heavy metals in study sites ranged between 0.299 $\mu\text{g/L}$ for Ni in winter 2010 and 168.02 $\mu\text{g/L}$ in summer 2010 for Fe. Variability in the distribution of metals appeared to be more related to hydrobiological condition [6]. The components also were washed from the atmosphere through run-off, wind blown dust, forest fire and volcanic particles, adding to the distribution of heavy metals in water [35, 36]. Seasonal variation in heavy metals concentration in river water has arisen as a result of the rapid growth of population, increased urbanization and expansion of industrial activities [37]. The level of heavy metals recorded in water in this study low when compared with the limited values suggested by WHO [28] and USEPA [38].

The concentration of heavy metals in particulate

phase found in this gradual $\text{Ni} < \text{Pb} < \text{Co} < \text{Cu} < \text{Mn} < \text{Fe}$. Sediments represent one of the ultimate sinks for heavy metal discharge into the environment, mean seasonal concentrations of sediment heavy metals in study sites on Euphrates River are illustrated in Figs. 3-4.

The results showed high concentrations of heavy metals in exchangeable and residual phase of sediment in the river under study, This concentration ranged between (0.050 $\mu\text{g/g}$) for Ni in spring 2010 in (st. 2) as minimum concentration and (146.67 $\mu\text{g/g}$) for Fe in spring 2010 in (st. 1) as maximum concentration to exchangeable phase and (0.065 $\mu\text{g/g}$) for Ni and (128.17 $\mu\text{g/g}$) for Fe in (st. 1), Autumn 2009 to residual phase.

The high concentration recorded in the sediment may be attributed to discharge of untreated sewage and industrial materials that contain metals as well as the ability of the sediment to act as sink [39].

Heavy metal contamination in sediment can effect the water quality and bioaccumulation of metals in aquatic organisms, resulting in potential long term implication on human health and ecosystem [40]. In addition, excretion and elimination of exoskeletons by abundantly occurring plankton and by settlement of particulate matter probably have played a significant role in enhancing the concentration of heavy metals in the sediments [6]. The behavior and distribution of heavy metals in sediments may be affected by water hydrology and many biological, chemical and geological operations occur in aquatic system [1].

4. Conclusion

- The variation of water quality was according to vary of seasons and study sites;
- The high concentration of heavy metals in sediment was more than water of Euphrates River.

The present information of physico-chemical properties, heavy metals in water and sediments would form a useful tool of ecological assessment and monitoring of ecosystem in Euphrates River.

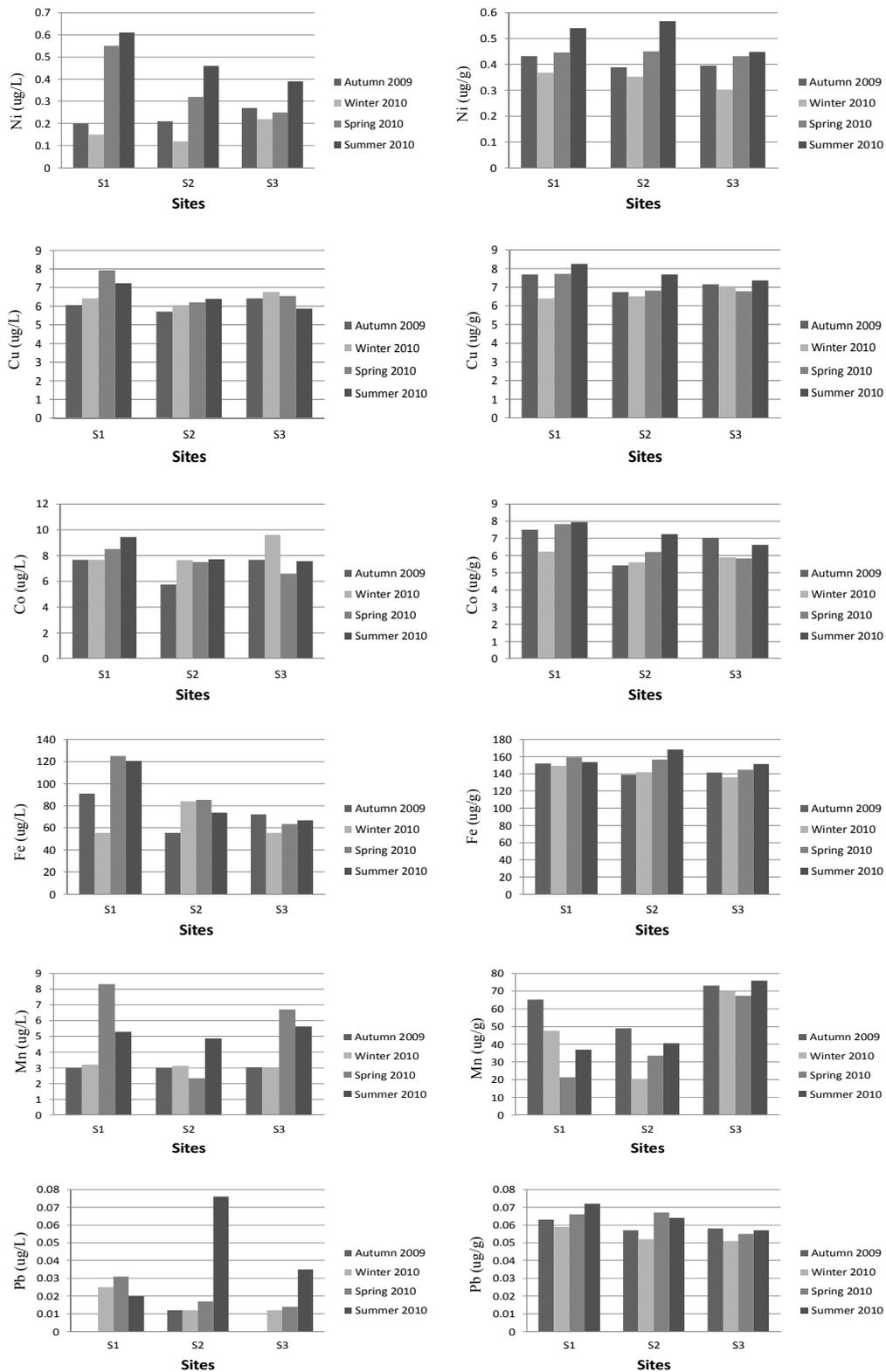


Fig. 1 Nickel, copper, cobalt, iron, manganese and lead concentration in the dissolved (left) and particulate phase (right) in the water of Euphrates River.

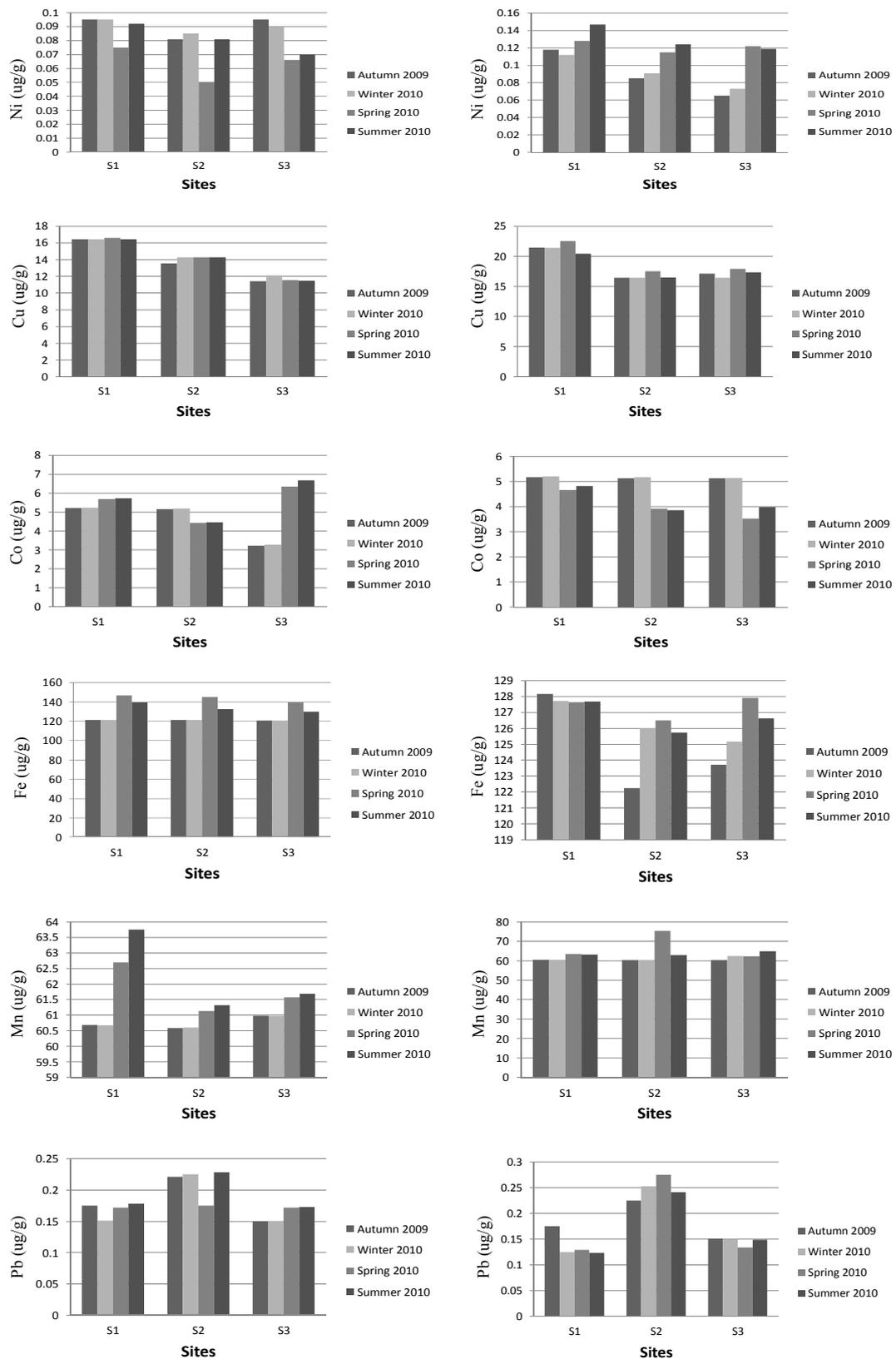


Fig. 2 Nickel, copper, cobalt, iron, manganese and lead concentration in the exchangeable (left) and residual phase (right) in the water of Euphrates River.

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