Environmental Geochemistry of River Nile Bottom Sediments Between Aswan and Isna, Upper Egypt

Ahmad Mohamed El-Kammar, Bataa Hussein Ali, and Abdel-Monsef Mohamed El-Badry

Abstract: The pollution of the River Nile bottom sediment is indicative of water and food-web quality in general. About 60 samples were collected from the upper 50 cm of the Nile bottom sediments between Aswan due south and Isna due north. The sampling considered the eastern and the western banks as well as the middle of the Nile course. Collaborating analytical techniques have been employed to analyze group of environment-sensitive elements, including; Pb, Cd, Ni, Co, Cu, V, Zn, U, Th and Ra. Standard sequential extraction procedure was employed on polluted samples to determine the bioavailability of the pollutants. The present study documents serious pollution by Cd in the vicinity of the phosphate-shipping harbors at the eastern and western banks of Sibaiya area. The average Cd content in the study area (3.1 ppm) is about 6 fold the maximum permissible limit (MPL = 0.5 ppm) of soil while the highest concentration (5.8 ppm) is more than 10 fold the MPL. Cadmium is more mobile in aquatic environments than most other heavy metals. The areas around Isna harbors and along Aswan dam show marked pollution by Pb which reaches 271ppm. The main reason for such Pb pollution is the fuel combustion from heavy traffic. However, there is insignificant signature of pollution by other heavy metals such as Ni, Co, Zn, V and Cu. The phosphorite mining and shipping area between Sibaiya and Mahamied exhibits marked pollution signature by uranium (up to 8 ppm). Knowing that almost half of the uranium content in phosphorite is soluble in the hexavalent state, significant amount of uranium must have been drained due north with Nile current. Radon and uranium have mutual distribution, while thorium is not. The sequential extraction data indicate that the insoluble fraction remains the main sink of zinc, copper and cobalt. Almost half the content of cadmium, lead and vanadium occurs in a bioavailable state; as exchangeable and carbonate-bound cations. Nickel mostly associates the iron oxy-hydroxides fraction. The unsupervised anthropogenic activities are the main causes of pollution in the Nile sediments. Routine program for monitoring the abundance and distribution of Cd, Pb and U in the Nile water, biota, sediments and food chain should be imposed.

Key words: River Nile, bottom sediments, pollution, Cd, Pb, U, sequential extraction, Egypt

INTRODUCTION

The River Nile drains materials of different source rocks (igneous, metamorphic and sedimentary) along its course from the central and eastern parts of Africa in the south to the Mediterranean Sea in the north (about 6285 km). The geology and origin of the study area, as a part of the River Nile, has been treated by many authors. Indeed, enrichment or deficiency of certain elements within rocks, soils or water may be responsible for certain diseases in plants, animals and humans. Elements such as Ni, Co, Cd, Pb and U are usually described as potentially toxic and can be considered as probable etiological agents. Several types of pollution were found in the alluvial environment as organic materials as well as major and trace metals. Pollution may be derived from dust fall, erosion, chemical weathering or from decay of dead aquatic organisms. The pollution also may be derived from human activity as industrial and agricultural activities or from sewage and ship’s wastes.

Mineral composition of the River Nile sediments have been discussed by many authors, recorded that the relatively high value of trace metals and organic matter in the River Nile near Cairo may be attributed to the effect of sewage and industrial pollution. Recently, studied the chemical speciation of some heavy metals in the River Nile sediments near Cairo District and concluded that clay fraction constitutes a major source of persistent bioaccumulative toxic chemicals.

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The present study may increase the awareness of pollution caused by some heavy metals that are exceptionally high in some parts of the area from Aswan to Isna. The area covers about 150 km along the River Nile and is located between longitudes 33° 15' 00" and 33° 25' 00"E and latitudes 28° 55' 00" and 29° 07' 00"N.

**Pollution Sources:** The sediments act as “sink” for metal contaminants, and risk increases with increasing metals leachability. The impact of such heavy metals abnormality may extend to involve the water quality and food web, and hence the human health. In the study area, source(s) of the toxic metals could be natural or anthropogenic. The latter is represented by claystone and phosphorite mining and sand quarrying activities. In addition, there are some polluting industries as the nitrogen fertilizer factory at Aswan, the sugar and diary factory at Kom Ombo and several other factories such as the pulp and paper, ferrosilicon and phosphate up-grading factories at Edfu. On the other hand the natural sources of pollution are the drains of the Eastern Desert, especially during the seasonal flash floods.

**Sampling and Techniques:** Bottom sediment samples were collected from the main Nile course between Aswan and Isna. About sixty samples were collected to represent the eastern flank, middle of the course and western flank of the Nile at samples interval of 5-7 km for 20 stations (Fig. 1) Samples were essentially taken from the upper 50 cm of the Nile sediments at water depth ranging from 1 to 10 meters. After air drying, samples were disintegrated and representative quotient was thoroughly pulverized to -100 mesh size then kept for chemical analyses. The chemical analyses were conducted on whole sediment samples for the trace elements; Pb, Ni, Co, Cu, Zn, Cd, and V using computerized X-ray fluorescence of Philips PW/2404, with Rh radiation tube and eight analyzing crystals including (LIF-200) for estimating trace elements. Equivalent uranium, thorium and radium (eU, eTh and Ra) were radiometrically analyzed using gamma-ray spectrometric multichannel analyzer. These analyses were done in the Egyptian Nuclear Material authority laboratories.

**Geochemical Backgrounds:** The comparison between the present data and the average earth’s crust, quoted by McLennan and Taylor [14] in Table 1, illustrates the following inferences:

- The average contents of V, Ni and Co in the studied sediments (320.2, 65.5, 24.5 ppm) are about 6, 3 and 2 fold the average earth’s crust, respectively
- Cd (from 3.1 to 5.8 ppm) is more than 6 and up to 30 fold the average earth’s crust.
- Not like other heavy metals, Zn and Cu (113.9 and 42.1 ppm, respectively) are slightly higher than average earth’s crust, while Pb (10.1 ppm in average) is eventually depleted to half the content of the crust.

Comparing with the U.S. Public Health Service [36], which established the freshwater sediment quality guidelines in the form of level of probable effects (PEL), the studied sediments seem to be polluted at different levels (Table 1). The analyzed heavy metals (Cr, Co, Cu, Ni, Zn, Cd, Pb and V) are not intimately correlated to each other as they have different speciation and sources. The elements; Cr, Co, Ni and V are strongly related to each other, but moderately correlated to Cu and Zn. The two potentially toxic metals (Cd and Pb) do not show any significant coherence to all other heavy metals (Fig.2). This can be held as a diagnostic criterion for their independent source.

**The Regional Pollution Index (Rpi):** The degree of pollution of the Nile bottom sediments can be calculated by normalizing the metals concentration to their maximum permissible limits (MPL) used for the worldwide soil [10]. In the given equation of the pollution index, the MPL of an element is considered as the “pollution standard level or goal”. The index of an individual pollutant is calculated as follows:

\[
\text{Pollution Index} = \frac{\text{Pollution concentration}}{\text{Pollutant standard level or goal}} \times 50
\]

![Fig. 1: Samples location map of the study area.](image-url)
Table 1: Average heavy metals of the present work compared with average earth crust according to McLennan and Taylor (1999), average data of Omer (2003), Abdel-Satar (2005), Moalla et al.(2006), average shale (Mason and Moor, 1982) and freshwater sediments according to USPH, (1997). All data are given in ppm.

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>3</td>
<td>0.5</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>42</td>
<td>25</td>
<td>116</td>
<td>27</td>
<td>36</td>
<td>45</td>
<td>50</td>
</tr>
<tr>
<td>Ni</td>
<td>66</td>
<td>20</td>
<td>74</td>
<td>44</td>
<td>n.d.</td>
<td>45</td>
<td>80</td>
</tr>
<tr>
<td>Co</td>
<td>24</td>
<td>10</td>
<td>43</td>
<td>49</td>
<td>14</td>
<td>n.d.</td>
<td>20</td>
</tr>
<tr>
<td>Zn</td>
<td>114</td>
<td>70</td>
<td>227</td>
<td>162</td>
<td>170</td>
<td>&lt;100</td>
<td>90</td>
</tr>
<tr>
<td>Pb</td>
<td>10</td>
<td>20</td>
<td>51</td>
<td>23</td>
<td>16</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

n.d.: not detected

RESULTS AND DISCUSSION

Distribution of Potentially Toxic Metals:

Cadmium (Cd): Cadmium is more mobile in aquatic environments than most other heavy metals, e.g. lead. Igneous and metamorphic rocks have low values of Cd from 0.02 to 0.2 ppm, whereas sedimentary rocks may have more higher values (0.1 to 25 ppm) [5]. According to Kabata-Pendias [10], the maximum permissible limit (MPL) of Cd in cultivated soil is 0.5ppm. The Department of Health and Human Services (DHHS) has determined cadmium and cadmium compounds as carcinogens, therefore, the Environmental Protection Agency (EPA) has set a limit of 5 ppb of cadmium for drinking water.

In the present study, the Cd content ranges from 0.9 to 5.8ppm with an average value of 3.1ppm. The frequency distribution of Cd is unimodal with maximum at about 2ppm (Fig.3). The distribution pattern is strongly skewed towards the higher concentrations, where about half of the analyzed samples contain more than 2 ppm. Therefore, the average content of Cd in the study area is more than 5 fold the MPL of soil as quoted by Kabata-Pendias, [10], while the highest Cd content (5.8 ppm) is more than 10 fold. Generally cadmium being more mobile in aquatic environments than most other heavy metals [1], it can be a serious pollutant for the Nile bottom sediments of Upper Egypt. It mostly related to phosphate shipping and production. The phosphate fertilizers are also possible source where Cd accumulates in the sugar can crops growing along the riverbanks. Fossil fuel combustion and some industrial activities may also contribute far more too human cadmium exposure (Fig.4).
Table 2: Average heavy metals of the present work compared to the average of the maximum permissible limit (MPL) in the worldwide soils (According to Kabata-Pendas, 1995) and regional pollution index (RPI).

<table>
<thead>
<tr>
<th>Elements</th>
<th>Present study (ppm)</th>
<th>MPL (ppm)</th>
<th>RPI</th>
<th>Type of pollution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>3</td>
<td>0.5</td>
<td>50</td>
<td>High</td>
</tr>
<tr>
<td>Cu</td>
<td>42</td>
<td>100</td>
<td>21</td>
<td>Low</td>
</tr>
<tr>
<td>Ni</td>
<td>66</td>
<td>100</td>
<td>33</td>
<td>Medium</td>
</tr>
<tr>
<td>Co</td>
<td>24</td>
<td>50</td>
<td>24</td>
<td>Low</td>
</tr>
<tr>
<td>V</td>
<td>320</td>
<td>60</td>
<td>267</td>
<td>High</td>
</tr>
<tr>
<td>Zn</td>
<td>114</td>
<td>300</td>
<td>19</td>
<td>Low</td>
</tr>
<tr>
<td>Pb</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>Medium</td>
</tr>
<tr>
<td>U</td>
<td>2.6</td>
<td>1.0</td>
<td>132</td>
<td>High</td>
</tr>
</tbody>
</table>

Fig. 3: Frequency distribution of cadmium (ppm) in the studied area

Fig. 4: Geochemical map of Cd (ppm) in the studied Nile bottom sediments. (Notice that the horizontal E-W, scale is exaggerated 100 fold)

Lead (Pb): Among all metals; Pb, Cu and Zn are in the closest relationship to humans; however, Pb is damaging to the human body. In the present work, the total lead content displays a wide range of concentrations ranging from 1 to 271 ppm with an average 10 ppm (Fig.5). The highest values are recorded near Isna harbor and along Aswan dam. This favors the belief that the emissions due fuel combustion and heavy traffic could be the main possible causes of Pb pollution.

The MPL of Pb in the worldwide soils is 20 ppm, hence, the polluted areas are localized and restricted near the heavy traffic and arsenal workshops near Isna and Aswan (Fig.6). According to the Agency for Toxic Substances and Disease Registry [3,4] soil lead contamination from mine tailings may be less effective in increasing PbB (blood lead) levels than its lead contamination derived from urban lead pollution (paint, gasoline) or atmospheric lead fallout from lead smelting operations.

Vanadium (V): V content ranges from 36 to 619 ppm, averaging 320 ppm. The highest content is ten fold the MPL (60 ppm). The simple frequency distribution of V in the studied sediments indicates that 70% of the analyzed samples contain below 300 ppm, while 30%
of the samples contain >300 ppm (Fig. 7). It was noticed that V content increases gradually toward the north, with several anomalous patches near the main cities and close to Isna Barrage, possibly due to relatively high sedimentation at its front, as well as combustion of fossil fuels, particularly fuel oil, which seems to be the main anthropogenic source of V (Fig. 8).

Total Heavy Metals: In general, heavy metals (lead, copper, cadmium and nickel) produce their toxicity by forming complexes or "ligands" with organic compounds [9]. In the studied sediments the heavy metals distribution pattern is not uniform and it seems to be more likely related to anthropogenic activities. It shows gradual increase of pollution towards Isna Barrage (Fig. 9). The pollution before the barrage can be interpreted to slowing down water movement, hence higher sedimentation rate. The second order level of pollution is recorded near the main cities, mining areas and the wastewater drains. The change in concentration is possibly due to the release of these metals from different polluting sources.

Natural Radioactivity:
Uranium (U): According to [13], U and other actinides are of environmental concern. Uranium decays into other radioactive elements, such as radium, which can cause cancer. In the present study, the eU (radiometrically measured uranium) content varies between <1 and 8 ppm, while the content of eTh (radiometrically measured thorium) varies from 1 to 9 ppm. The highest values are recorded near the phosphate and shale mining areas. The present eU data are markedly higher than both of the averages quoted for worldwide marine sediments (2.3 ppm, U) and average upper continental crust (2.8 ppm) as quoted by
Taylor and McLennan,\textsuperscript{[33]}, but $c$Th value is lower than the averages of worldwide marine sediments (12.9 ppm).

The $c$U value increases (6 and up to 8.5 ppm) in the northern portion of the study area near to the phosphate mining area. This refers to possible toxicity by uranium and its daughters (Fig.10). No doubt that the mining, beneficiation and transportation of phosphorites trigger the pollution by uranium in the study area.

Fig. 10: Geochemical map of $c$U in the studied Nile bottom sediments.

Thorium (Th): In the study area, $c$Th ranges from 1 to 9 ppm, averaging 4.2 ppm. The content increases in the southern portion of the study area which can be attributed to the shale mining near Aswan. The geochemical map of $c$Th indicates that the highest pollution occurs near the shale mining North Aswan (9 ppm) while the minimum value (1 ppm), is recorded in most samples of the northern part of the study area (Fig.11).

Fig. 11: Geochemical map of $c$Th in the studied Nile bottom sediments.

Radium (Ra): Ra is formed when uranium and thorium decay in the environment. It gives off gamma radiation, which can travel fairly long distances through air and may be dangerous to health \textsuperscript{[3]}. In the studied sediments, Ra ranges between 1 and 3 ppm, averaging 1.8 ppm. It increases gradually toward the north, with several patches located near the cities and relatively cultivated area (Fig.12). Ra accumulates near the shale mines north of Aswan and the phosphate mines near El-Sibaiya. The minimum concentration is 1 ppm and it represents background level in the study area. However, comparing the geochemical map of Ra with its parents, namely U and Th, the following observations can be assumed:

1. The U- and/or Th-rich zones are also rich in Ra. This is applicable for the phosphate and shale mining areas.
2. The ferrosilicon factory at Idfu and the sugar factory and the main drains at W. Idfu are not rich in U or Th, but anomalous in Ra. The straightforward explanation of such feature is that Ra has been introduced to the Nile sediments by sources other than the natural deposits of phosphate and shale. Generally, the total radioactivity points to the fact that the phosphate mining at El –Sibaiya area and the shale mining northern Aswan are the main locations suffering of high radioactivity. The radioactivity is mostly related to uranium and thorium, while potassium has insignificant contribution. The ferrosilicon and sugar industries contribute also to the total radioactivity.

Fig. 12: Geochemical map of Ra (ppm) in the studied Nile bottom sediments.
Sequential Extraction of the Heavy Metals: Heavy metals are found in various chemical forms in sediments and they display variable behaviour in terms of mobility, bioavailability and potential toxicity. Depending upon their relative mobility in different chemical forms, bioavailability of heavy metals decreases in the order: exchangeable \( > \) Carbonate \( > \) Fe-Mn oxy-hydroxides \( > \) organic \( > \) residual. Metals bound to the exchangeable fraction are readily available, whereas those included in the carbonate/adsorbed phases become more mobile and easily available with increasing acidity. The residual fraction is considered to represent the unreactive phase. The following is an attempt to throw more light on the way by which the heavy metals are linked to the mineral constituents whether primary or weathering products. The sequential extraction scheme followed in the present study is adopted after Tessier, et al.

Sequential Extraction Procedure: The sequential extraction of the heavy metals; Ni, Cu, Zn, Co, Pb, Cd and V is conducted on representative samples in order to assess the potential mobility and bioavailability of these metals in the studied sediments. One gram of each sample is weighed into a 40 ml PVC tube and the following five fractions are obtained: (1) The exchangeable fraction is extracted with 8 ml of 1M MgCl\(_2\) at neutral pH for 1 h. (2) The carbonate-bound fraction is extracted with 8 ml of 1M Na acetate (adjusted to pH 5) for 5 h. (3) The Fe-Mn oxy-hydroxides-bound fraction is extracted with 0.04M hydroxylamine-HCl in 25% (v/v) acetic acid at 96°C with occasional stirring for 6 h. (4) The organic-bound fraction is extracted with 3 ml of 0.02M HNO\(_3\) and 5 ml of 30% H\(_2\)O\(_2\) (adjusted to pH 2 with HNO\(_3\)). The mixture is heated to 85°C for 2 h with occasional stirring. (5) The residual fraction is obtained by complete digestion of the residue with a mixture of HF-HCl/HNO\(_3\) in a digestion bomb. The overall recovery rates of the analyzed heavy metals range from 90 to 110 %.

The recovery of the heavy metals in each leaching step was estimated by atomic absorption spectrophotometer (Perkin-Elmer 2380) equipped with a graphite furnace atomizer. A set of natural and artificial materials were used as standards for the analysis of each extraction steps in the same matrix as the extracting reagents.

Cadmium (Cd): Unlike the investigated heavy metals, Cd shows a distinctive partitioning pattern in the examined sediments. It is dominated in the exchangeable (15.8-30.2% with an average 25.6%), residual (17.4-32.5% with an average 25.1%) and carbonate (15.8-23.4% with an average 20.1%) fractions, followed by the reducible and oxidizable fractions. This indicates that the exchangeable and carbonate fractions are the main modes of Cd and they could be related to anthropogenic activity. This conclusion agrees with Lashin and Ammar. The association of Cd with the exchangeable phase agrees with Siegel who noted that >20% of Cd is an available form easily soluble and exchangeable phases (Fig.13).

Vanadium (V): Peacock and Sherman reported important data on the adsorption via surface complexation of vanadium on goethite under different pH values. They suggested the following empirical equations to explain such adsorption;

\[
2\text{FeO}_2\text{H}^+ + \text{VO}_2^- = \text{Fe}_2\text{O}_5\text{V(OH)}_3^+ + 2\text{H}^+
\]
\[
2\text{FeOH}^+ + \text{HVO}_2^2- = \text{Fe}_3\text{O}_5\text{VO(OH)}^6\text{V} + 2\text{OH}^-
\]

The above assumptions can interpret the high concentration of vanadium in the Fe-Mn oxy-hydroxides fraction, which accumulates up to 22.9% of the total vanadium content (Fig.14). The highest exchangeable quotient among the analyzed heavy metals is determined for vanadium (10-51%, averaging about 27%). However, vanadium is diagnostically distributed among the five fractions with relatively high rates for the first three fractions (about 72% of total V content) while the organic bound and insoluble fractions represent 11 and 18% in average, respectively. These data suggest that vanadium is a highly mobile element with marked bioavailability.
Conclusions: The present work is based on chemical analysis and sequential extraction data on the bottom sediments of the River Nile between Aswan and Isna. Sixty samples were collected from the eastern flank, middle stream and western flank of the Nile from 20 stations along a segment of about 150 km long. Relative to average earth's crust, the Nile sediments are markedly enriched in Cd and slightly enriched in V, Co and Ni. The calculated pollution index nominates Cd, V and U as pollutants of high level, while Ni at medium level. Mining, transportation and beneficiation of phosphorites between Idfu and Isna seem to be main source of pollution by Cd and U. The U- and Th-rich zones are also polluted with respect to Ra.

Significant proportions of Cd, Pb, V, Co, and Cu are hosted in the exchangeable and carbonate-bound fractions reflecting their important role as pollutants. Owing to the clear poverty of the studied sediments in the clay size fraction and to the prevailing arid conditions, the bioavailable fraction of these heavy metals is expected to be remarkably restricted. However, V seems to be the most bioavailable where the exchangeable and the carbonate-bound fractions cover more than 50% of the total V content (Table 3).

The insoluble phase is the essential modes of Cu. The extreme fractionation of Cu indicates its duel existence as anthropogenic (incorporated with organic fraction) while the prevalence of Cu in the residual and natural (lithogenic) pollutant. The main quotient of Pb is associated with the exchangeable and reducible phases. The anomalous levels of Pb are accompanied by significant increase in the reducible fraction, suggesting anthropogenic nature.

Cadmium occurs mostly in the exchangeable and insoluble fractions, with an important proportion in the carbonat-bound fraction. This suggests that the main part of Cd is possibly anthropogenic. The concentration, speciation and distribution nominate Cd as the potentially toxic heavy metal in the studied bottom sediments of the River Nile between Aswan and Isna (Fig.15). Routine monitoring of Cd in the Nile bottom sediments is strongly recommended to mitigate from hazards of extreme levels of future pollution.

The significant part of Co and Ni is associated with the insoluble fraction while the exchangeable fraction represents the second dominant mode of cobalt. The significant part of these two elements is associated with the Fe-Mn oxy-hydroxide phase (Table 3 and Fig. 15).

Fig. 14: Sequential extraction pattern of V from the studied sediments

According to Rieuwerts, et al. [23], the bioavailability of metals in soils depends, to a large extent, on their distribution between the solid and solution phases. This distribution is, in turn, dependent on:

1- The soil processes of cation exchange,
2- Specific adsorption, precipitation and complexation.
3- pH is the most important influencing factor on metal bioavailability in soils, with solubility and pH usually showing an inverse relationship. The presence of clays and hydrous Fe and Mn oxides tends to increase metal adsorption and thus reduce soluble metal contents, whilst the effects of organic matter content and redox potential are more uncertain.

The obtained results on the sequential extraction show that the metal speciation pattern is controlled by the source and geochemical behaviour of metals, hence the degree of pollution and the major parts of Cd, Co, Cu and Zn are hosted in the insoluble fraction reflecting their natural association in the crystalline silicate minerals besides the Fe oxy-hydroxides.

Fig. 15: Average sequential extraction patterns of the analyzed heavy metals in the studied Nile bottom sediments
Table 3: Averages of some heavy metals recovery (%) from the studied sediments

<table>
<thead>
<tr>
<th>Sequential extraction</th>
<th>Cadmium</th>
<th>Lead</th>
<th>Vanadium</th>
<th>Cobalt</th>
<th>Nickel</th>
<th>Copper</th>
<th>Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchangeable</td>
<td>25.6</td>
<td>30.0</td>
<td>27.4</td>
<td>19.9</td>
<td>16.1</td>
<td>8.5</td>
<td>9.0</td>
</tr>
<tr>
<td>Carbonate-bound</td>
<td>20.1</td>
<td>17.3</td>
<td>21.3</td>
<td>15.9</td>
<td>18.4</td>
<td>4.1</td>
<td>11.2</td>
</tr>
<tr>
<td>Fe-Mn hydroxide bound</td>
<td>16.5</td>
<td>20.8</td>
<td>22.9</td>
<td>12.2</td>
<td>33.7</td>
<td>7.2</td>
<td>18.1</td>
</tr>
<tr>
<td>Organic bound</td>
<td>12.7</td>
<td>14.3</td>
<td>10.6</td>
<td>8.5</td>
<td>15.8</td>
<td>6.2</td>
<td>11.7</td>
</tr>
<tr>
<td>Insoluble</td>
<td>25.1</td>
<td>17.5</td>
<td>17.8</td>
<td>43.5</td>
<td>15.9</td>
<td>73.9</td>
<td>50.0</td>
</tr>
</tbody>
</table>

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