HEAVY METALS CONCENTRATION IN THE WATER AND SEDIMENTS OF LOHAN RIVER, RANAU

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ABSTRACT

The Lohan River is one of many river systems in the Ranau region which was once severely affected by the Mamut copper mine. The purpose of this study was to assess the level of heavy metals in the water and sediments of the Lohan River. Sampling was done on 26th November 2008. Water and sediment samples were collected from four sampling stations along downstream of the Lohan River. Water samples were filtered with a 0.45-μm membrane filter and acidified to pH<2 prior to analysis, whereas sediment samples were digested using aqua regia for the determination of total heavy metal concentrations. 10 heavy metals (i.e. As, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, and Zn) were analyzed for this study, both in water and sediment samples collected. The results obtained were then compared with the Interim National Water Quality Standards (INWQS) for Malaysia, the United Nations Food and Agriculture Organization (UNFAO) irrigation water standards, and for sediment analysis, the Provincial Sediment Quality Guidelines (PSQG) Ontario, Canada. Sample analyses were conducted by means of an Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES). From the results obtained, only three heavy metals – Cd, Cu, and Mn – showed non-compliance with the Malaysian INWQS threshold limits, whereas cadmium was the only element to have exceeded its UNFAO recommended maximum for irrigation water. For sediment analysis; with reference to the PSQG; As, Cd, Cr, Cu, Fe, and Ni showed concentrations in Lohan River to exceed their respective Severe Effect Levels (SEL). This is an indication of heavy pollution of Lohan River’s sediments in terms of the mentioned heavy metals. The trend of heavy metal concentration in Lohan River’s water was Fe>Mn>Ni>Cu>As>Zn>Cd>Co>Pb>Cr, whereas in sediment the trend was Fe>Cu>Ni>Mn>Cr>Zn>Pb>Co>As>Cd.
ABSTRAK

Sungai Lohan merupakan salah satu sungai di kawasan Ranau yang pernah pada suatu masa dahulu teruk terjejas oleh lombong tembaga Mamut. Tujuan kajian ini adalah untuk mengkaji tahap logam berat di dalam air dan sedimen Sungai Lohan. Persampelan telah dibuat pada 26 November 2008. Sampel-sampel air dan sedimen diambil daripada empat stesen persampelan sepanjang Sungai Lohan ke hilir. Sampel air dituras menerusi membran penuras 0.45-μm dan diasidkan ke pH<2 sebelum analisis dijalankan, manakala sampel sedimen dihadamkan dengan aqua regia untuk penentuan konsentrasi logam berat keseluruhan. 10 jenis logam berat (i.e. As, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, dan Zn) telah dianalisis untuk kajian ini dalam sampel air dan sedimen yang telah di kumpulkan.

Keputusan yang diperolehi di bandingkan dengan Piawaian Kualiti Air Kebangsaan Sementara Malaysia (INWQS), piawaian air pengairan Organisasi Makanan dan Pertanian Pertubuhan Bangsa-Bangsa Bersatu (UNFAO), dan untuk analisis sedimen, Garis Panduan Kualiti Sedimen Wilayah (PSQG) Ontario, Kanada. Analisis sampel dibuat dengan penggunaan alat Inductively Coupled Plasma – Optical Emission Spectrometer (ICP-OES). Daripada keputusan yang diperolehi, hanya tiga logam berat - Cd, Cu, dan Mn - tidak memenuhi INWQS Malaysia, manakala kadmium merupakan elemen tunggal yang telah melampaui konsentrasi maksimum yang disyorkan oleh UNFAO bagi air pengairan. Bagi analisis sedimen; merujuk kepada PSQG; As, Cd, Cr, Cu, Fe, dan Ni menunjukkan konsentrasi dalam Sungai Lohan melebihi Severe Effect Level (SEL) yang ditetapkan masing-masing. Ini menunjukkan keadaan sedimen Sungai Lohan yang kuat tercemar oleh logam-logam berat tersebut. Trend konsentrasi logam berat di dalam air Sungai Lohan yang telah ditentukan adalah Fe>Mn>Ni>Cu>As>Zn>Cd>Co>Pb>Cr, manakala untuk sedimen trendnya adalah Fe>Cu>Ni>Mn>Cr>Zn>Pb>Co>As>Cd.
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<tr>
<td>mgL(^{-1})</td>
<td>milligram per liter</td>
</tr>
<tr>
<td>µgL(^{-1})</td>
<td>microgram per liter</td>
</tr>
<tr>
<td>mgkg(^{-1})</td>
<td>milligram per kilogram</td>
</tr>
<tr>
<td>µgg(^{-1})</td>
<td>microgram per gram</td>
</tr>
<tr>
<td>ppm</td>
<td>parts per million</td>
</tr>
<tr>
<td>mL</td>
<td>milliliter</td>
</tr>
<tr>
<td>H(_2)SO(_4)</td>
<td>sulphuric acid</td>
</tr>
<tr>
<td>HCl</td>
<td>hydrochloric acid</td>
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<td>HNO(_3)</td>
<td>nitric acid</td>
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CHAPTER 1

INTRODUCTION

1.1 Importance of Water

Water is a basic and essential necessity to living organisms. Without water, earth would not sustain as we know it and many things would not be possible. All living things consist of 60 to 95 percent water (Biswas, 1997). Even the basic unit of living systems; cells, are approximately 85 – 95% water (Somero et al., 1992). Water is the essence of life. In addition, water is the universal solvent – it can dissolve a good range of compounds from simple salts to minerals - and it also reacts with complex organic compounds such as the many amino acids found in the human body (Botkin and Keller, 2005). Water has many important roles and functions in the human community as well; it is widely used for irrigation, sewage, food processing, and for a number of industrial purposes.

In the past, great civilizations developed and flourished on the banks of rivers such as the Nile, Euphrates, Tigris, and Indus. Human history can generally be considered to revolve around water (Biswas, 1997). However, important as it is to humans; plants and animals need water just as much as we do and survival has every bit to do with the
availability of clean water supplies. The quality of water is therefore of utmost importance for both the well-being of humans and the balance of ecosystems alike.

1.2 The Water Resource Problem

While the importance of water is known to many, few are aware of its vulnerability. With about 97% of the earth's water in the oceans (saline), freshwater only accounts for a meager 2.5% (Radojevic et al., 2007). Yet, not all of this 2.5% are readily available for human use – most are locked up in ice caps and glaciers. The growing population and industrial production will accelerate the use of already-scarce water supplies (Botkin and Keller, 2005), not forgetting the increasing pollution and contamination - which would only make things worse.

With the rising awareness of water scarcity in recent years, it is of much concern if the earth’s water supplies can stand our increasing demands – just about three decades back in 1975, the total human use of water was about 3850 km\(^3\)/year; in 2005 this figure increased to about 6000 km\(^3\)/year, which is a generous portion of the naturally available freshwater (Botkin and Keller, 2005).

This problem becomes more complex with the fact that water resources are not evenly distributed (Vajpeyi, 1998). Already limited in amount, freshwater may not even be present at places where it is needed most. It is a great challenge to find sufficient
freshwater resources and at the same time maintain its quality. The quantity of water itself may not be a problem at the global level; however the issue is on finding good quality freshwater at the time and place (when and where) it is needed (Radojevic et al., 2007).

1.3 Water Pollution

The pollution and contamination of water resources further reduces the availability of already-limited supplies. When the quality or composition of water gets changed – either naturally or as a result of human activities – so as to become less suitable for drinking, domestic, agricultural, industrial, recreational, wildlife and other uses for which it would have been otherwise suitable in its natural or unmodified state; the water can be regarded as being polluted (Goel, 2006). In general when defining pollution, the following are considered; the intended use of the water, how far its quality differs from the norm, its effects on public health or its ecological impacts (Botkin and Keller, 2005).

There are many ways in which water can be polluted. Human use of water degrades the quality of water as it involves various types of pollutants. While natural water bodies such as the oceans and streams have innate purification abilities, these are limited to only certain levels of pollution. Once the purification potential is exceeded, the water body is vulnerable to contamination whether in the form of biological, physical or chemical pollutants. These are threats to living organisms including humans. (Radojevic et al. 2007).
Water pollutants include heavy metals, sediment, certain radioactive isotopes, heat, fecal coliform bacteria, certain pathogenic bacteria and viruses, nitrogen, sodium, phosphorus as well as a range of other elements. A material may in certain instances be considered a pollutant to a particular segment of the population although it is harmless to other segments (Botkin and Keller, 2005). It depends on the conditions and parties involved.

There are different levels of water quality for different purposes of water use. Like for example, drinking water would require more stringent standards than that of water used for irrigation. Water pollution is often linked to public health. Humans can get ill from drinking, washing or bathing in contaminated water (Radojevic et al., 2007). The frequent monitoring and maintenance of water quality would therefore help to prevent the emergence of epidemics and improve the quality of life in general.

1.4 The Malaysian Scenario

Ever since the country’s economy shifted towards industrialization in the 1980s followed by population increase and urban growth, the demands for residential and industrial water supply has greatly increased (WWF-Malaysia, 2007). Water scarcity and pollution became increasingly important matters. In 1995, Malaysia recorded a total freshwater withdrawal of 12.73 km³/yr. Out of this amount, 10% was used for domestic purposes, 13% for industrial purposes, and 77% used solely for agriculture (UN FAO, 1999). More
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