Heavy Metal Assessment of Kavre Valley Basin River System

Siddhartha Shakya, Prekshya Gurung, Anjal Bohaju, Dipson Ojha and Bhim Prasad Kafle

Abstract: Recent population growth, industrialization and unplanned urbanization have led to an increase in untreated waste disposal directly to the river system, including heavy metals. The present investigation was conducted for assessment of heavy metals in the Kavre valley river basin system. Through this basin, two major rivers Punyamata and Roshi along with their tributaries, flow passing through cities (Banepa, Shree Khandapur and Panauti) and the heavy metals selected were Iron (Fe), Chromium (Cr), Manganese (Mn), Lead (Pb), Zinc (Zn) and Cadmium (Cd). Seven sites were selected on the basis of city size and meeting point of tributaries. Fe, Cr and Mn were examined using UV-spectrophotometry whereas Pb, Zn and Cd were determined using AAS. The highest concentration of Cr, Mn, Fe, Cd, Zn, Pb were determined to be 1.9 μg/L, 22.6 μg/L, 514 μg/L, 340 μg/L, 20 μg/L, 80 μg/L, respectively, with Fe, Cd and Pb exceeding the WHO limits.

Keywords: Heavy metal, Spectrophotometry, Kavre valley, Nepal

Introduction

Heavy metals are naturally occurring elements that have a high atomic weight and a density at least five times greater than that of water. Their toxicity depends on several factors including the dose, route of exposure, and chemical species, as well as the age, gender, genetics, and nutritional status of exposed individuals (G et al. 2012). Though some of the metals like Cu, Fe, Mn, Ni and Zn are essential as micronutrients for life processes in plants and microorganisms, many other metals like Cd, Cr and Pb have no known physiological activity, and they are proved to be detrimental beyond a certain limit (Kar et al. 2008).

Figure 1: Sampling sites (Source: Open street Map).

While water is a finite and vulnerable resource, it is increasingly becoming scarce and polluted. (Pandey et al. 2011). Therefore, continuous monitoring of the water resources must be made. Similar studies have been conducted in Kathmandu, Nepal for Bagmati river system (Kayastha 2015;Paudyal et al. 2016), but previous water body related studies in Kavre have only highlighted organic pollutants and none have focused on heavy metal pollution, which is also a major environmental and health concern.

Methodology

Study area

The study area covers mainly three cities: Banepa, Shree Khandapur and Panauti. The 16 km long Punyamata river is located 30 km east of Kathmandu and covers an altitude gradient of ca. 600 m (average slope: 4%) before the river confluences with the Roshi river at 1,370 m above sea level (Feld et al. 2010). The study area and sites are shown in Figure 1. The black dots along the blue river line indicate the sampling sites.

Sampling

The samples were collected in polypropylene bottles after thoroughly washing the bottles with detergent and tap water, then rinsed with 1:1 nitric acid, tap water, 1:1 hydrochloric acid, tap water, and finally with distilled water, in that order. To preserve the samples immediately after sampling, they were acidified with concentrated nitric acid (pH <2). For a 1-liter bottle, 10 ml of the acid was used. Seven sites were selected on the basis of meeting point of tributaries and entry and exit point of the river from densely populated areas.

Preparation of calibration curves

Chromium and Manganese were detected using UV-spectrophotometer through simultaneous detection while Iron was detected by APHA 3500 method within 7 days of sample collection. For manganese, the absorption peak was at 545nm whereas for chromium, it was 440nm.

Preparation of calibration curve for Mn

1M concentrated sulphuric acid was mixed with 0.7M phosphoric acid in the ratio 1:1 and a solution of 1 liter was made. Then, 0.01M potassium permanganate, with the help of solution made before, was diluted to make the concentration of 0.004M, 0.006M, and 0.008M. In this case, the blank used was the same solution of 1M concentrated sulphuric acid with 0.7M phosphoric acid. Then, with these five solutions, the standard curve for magnitude at 545nm was made by observing the absorbance.

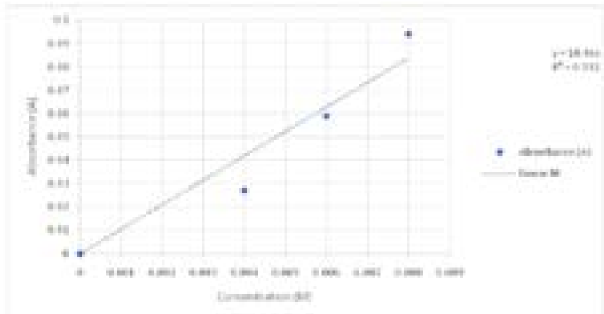

Figure 2: Calibration curve for Manganese

Preparation of calibration curve for Cr

1M concentrated sulphuric acid was mixed with 0.7M phosphoric acid in the ratio 1:1 and a solution of 1 liter was made. Then, stock solution of 0.01M potassium permanganate, with the help of solution made before, was diluted to make the concentration of 0.00033 M, 0.0005 M, 0.001M, and 0.006 M. In this case, the blank used was the same solution of 1M concentrated sulphuric acid with 0.7M phosphoric acid. Then, with these five solutions, the standard curve for magnitude at 440 nm was made by observing the absorbance.

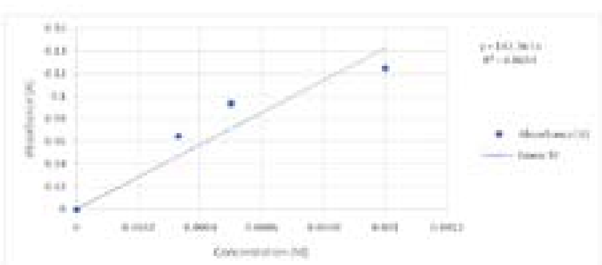

Figure 3: Calibration curve for Chromium

Calibration curve from iron was prepared using APHA 3500 method and the following data was obtained:

Cadmium, Lead and Zinc were determined using AAS by Aquatic Ecology Center (AEC) at Kathmandu University, Dhulikhel, Nepal.

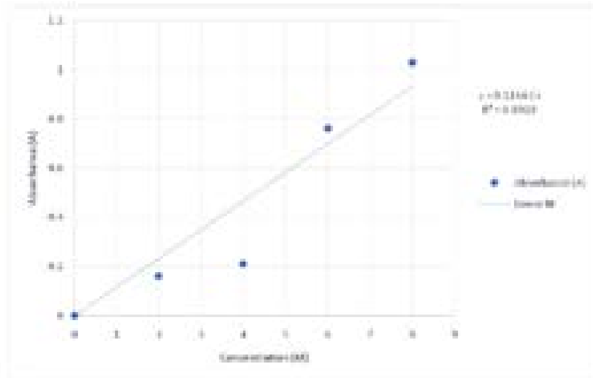

Figure 4: Calibration curve for Iron

Results and Discussions

Sample	Sampling site	Concentration (µg/L)					
		Chromium	Manganese	Iron	Cadmium	Zinc	Lead
B1	Banepa	0	1.5	111.5	340	20	40
B2	Banepa	1.3	14.5	514.6	290	ND(<20)	80
K	Shree Khandapur	1.9	22.6	428.8	170	ND(<20)	50
P1	Panauti	0.6	6.1	343	40	ND(<20)	30
PR	Panauti	0.2	2.5	111.5	ND (<3)	ND(<20)	20
R1	Panauti	0.2	2.3	8.6	ND (<3)	ND(<20)	60
R2	Khopasi	0.2	0.9	8.6	ND (<3)	ND(<20)	40

Table 1: Observed conditions of heavy metals in each sampling site

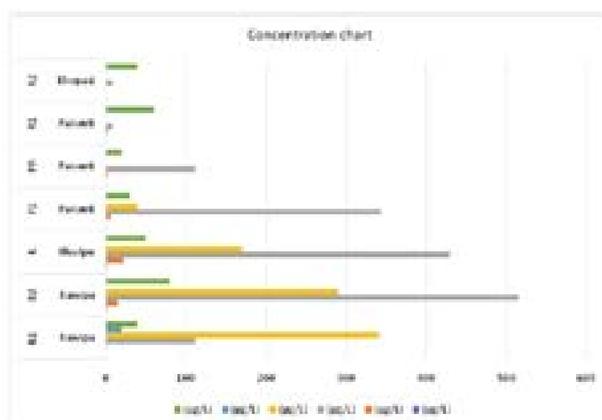

Figure 5: Sampling site along Kavre valley basin river system VS heavy metal concentration

From Figure 5, we can see that Shree Khandapur shows the highest concentration of Cr (1.9 µg/L) and Mn (22.6 µg/L) while Banepa shows the highest concentration of Fe (514.6µg/L), Cd (340 µg/L), Zn (20 µg/L) and Pb (80 µg/L). The concentration of Cr is quiet low, compared to other heavy metal concentrations. The WHO recommended maximum allowable concentration of Cr, Mn, Fe, Cd, Zn and Pb are 50 µg/L, 500 µg/L, 300 µg/L, 3 µg/L, 300 µg/L and 10 µg/L (WHO, 2017) respectively. It can be observed that the concentration of Cd and Fe decreases as they pass through Banepa. We can also observe that among the highest concentrations of the different heavy metals, the concentration of Fe, Cd and Pb exceeds the WHO limits.

Conclusion

Although the concentration of Cr, Mn and Zn are within WHO limits, the exceedance of Fe, Cd and Pb along with the organic waste makes the water highly contaminated and unsafe for daily use unless treated properly. The high heavy metal concentration in Banepa might be due to the direct discharge of small scale industries of Banepa directly into the river.

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Siddhartha Shakya *currently enrolled in B.Tech in Environmental Engineering in Kathmandu University, Nepal with professional goal in wastewater engineering.*

Corresponding address: shakya.siddhartha97@gmail.com

Co-authors Prekshya Gurung, *Anjal Bohaju and Dipson Ojha are enrolled in B.Tech in Environmental Engineering, Department of Environmental Science and Engineering of Kathmandu University, Nepal.*

Bhim Prasad Kafle *is an Assistant Professor in Department of Chemistry of Kathmandu University, Nepal.*

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