

# Comparative Study of Heavy Metals Accumulation in the Nails of Drinkers and Non-Drinkers of River Water

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## Abstract

Heavy metals can incorporate into humans by contaminated drinking water and can then be distributed into different tissues, which leads to an internal accumulation that can induce different alterations, adverse effects and acute/chronic metal poisoning. Nails can be used as bio-indicator for biological monitoring for the purpose of forensic examination in poisoning cases, assessment of metal exposures, as occupational marker and for health risk assessment. This paper deals with the comparative quantitative study of iron, lead, zinc, cadmium, copper and nickel concentration in nails of male subjects drinking and not drinking water from river. The levels of these metals were analyzed by Atomic Absorption Spectrophotometer (AAS). The result of this study showed Fe and Cu were significantly higher in concentration in the nail samples of people consuming river water whereas Zn concentration was slightly higher in the nail sample of people not consuming river water and Cd, Ni and Pb showed negative result in the both type of subjects. The present comparative study showed significant difference in heavy metal concentration in both the type of subjects. So it can be stated that people consuming river water are more affected, due to continuous exposure from these metal through the river. This study can prove that nail samples can be used as biological indicator and biological monitoring tool for assessment of heavy metal.

**Keywords:** heavy metals, nails, AAS, Biological monitoring, Bio-indicator, Forensic examination, Health risk assessment.

## Introduction

The effect of environmental exposure to heavy metals on human health has received a great deal of interest in recent years. People are exposed to variety of heavy metal pollutants that are released into the environment as consequences of their living place and workplace activities. These heavy metal pollutants can be incorporated into the human by drinking water and can be stored and distributed in different tissues, consequently have a potential to lead an adverse health effect and/or disease. Prayagraj is blessed with most scared and important rivers i.e Ganga, Yamuna and third mythical river "Saraswati" (the point where Ganga and Yamuna River meet is called as Saraswati, Sangam in Sanskrit). Due to increased urbanization and industrialization these rivers are under intimidation of high-water pollution, the

heavy metals contamination (such as- Mn, Cr, Pb, Zn, Fe and Cu) in the river water of various sites of Prayagraj region was found exceeding. <sup>1</sup>

Nail have many advantages when compared to other biological materials in monitoring heavy metals:

1. They can easily be sampled and analyzed for accumulated toxic and essential metals in the tissue. So nails can be used as bio-indicators. <sup>2-4</sup>
2. The higher concentrations of residues are found in nail samples, when compared to those on blood and urine.
3. Unlike blood that gives transient concentrations, nails can provide a continuous record of the metal concentration in body. <sup>5</sup>

4. The capacity of nail to accumulate metals during extended periods, reflecting up to 1 year of exposure.

Nail can be the ideal matrix for most common heavy metal forensic examination due to its reliability, nail as evidences can be easily transported and stored for longer period of time, obtained without injuring the donor, have significant role in identification of suspected death through heavy metal poisoning (e.g. arsenic), also socio-ethically better option than post-mortem medico-legal findings.

## Methodology

### (1) Studied Area and Sample Collection

Study area is situated in the southern part of Uttar Pradesh in the Prayagraj (Allahabad) district (fig.1). People living near Arail Ghat mostly depend on the river water for drinking purpose because most of the people's occupation is boat sailing and they do not carry water bottle with themselves, also because of spiritual believes that Ganga/Yamuna river water is the purest whereas as people living far from the river consume regular government tap water for drinking purpose.



**Figure-1** shows map of studied area.

Finger and toenail clipping from 10 people drinking river water (living near Arail Ghat) and 10 non-drinkers of river water were collected. In all 20 samples 6 metals were analyzed (Iron, Copper, Nickel, Zinc, Lead and cadmium). Distal edge/Free margin (margo liber) of nail plate were cut with clean stainless steel nail cutters. All the nail samples were sealed in plastic bags prior to analysis.

### (2) Procurement of Nail Samples

Nail samples of males (age range 30-50 year) were collected from both the types of subject. Following details of subject were collected:

- Gender
- Age
- Drinker or non-drinker of river water
- Occupation

Followed by this, fingernails and toenails of the relevant subjects were collected.

### (3) Washing of Nail Samples

The nail samples was kept soaked in non-ionic soap solution for 2 hours in a labeled glass beaker and wash to free from debris then the sample was soaked in acetone for 1 hour to remove external contamination subsequently sample was rinsed five times with distilled deionized water and finally oven dried at 60-110 degree Celsius and kept in desiccator for further procedure.

### (4) Digestion of the nail samples

Dried nail samples (0.5 grams) were placed in muffle furnace at 550 degree Celsius for four hours. After four hours in muffle furnace the nail samples became ash. The ashes were then digested with 10 ml of 6:1 mixture of concentrated nitric acid and per chloric acid, kept overnight at room temperature to prevent excessive foaming and subsequently the samples were heated at 160-180 degree Celsius until the mixture become water clear and reduces to 1 ml. Each sample solution was then diluted with 0.1N nitric acid and made to volume of 50ml with distilled water.

### (5) Analysis of heavy metal concentration in nail samples from AAS

Metal concentrations of each sample were assayed by using Perkin Elmer-400 AAS with air acetylene flame. A series of standards were prepared in deionized water for instrumental calibration by diluting commercial standards containing 1000 ppm of the metals. All reagent used were of analytical grade.

**Table-1** Parameter used for metal analysis in Atomic Absorption Spectrometer Unit (AAS) Perkin Elmer analyst 400 is shown in below table.

Name of Element	Wavelength (nm)	Sensitivity Check (ppm)	Standard Solutions for Metal (ppm)
Cadmium (Cd)	228.80	1.500	0.5 & 1.0
Zinc (Zn)	213.86	1.00	0.26 & 0.50
Lead (Pb)	283.31	20.00	5.0 & 10.0
Copper (Cu)	324.75	4.0	1.0 & 2.0
Nickel (Ni)	232.00	7.00	2.5 & 5.0
Iron (Fe)	248.33	5.00	1.5 & 3.0

### Results

The results of quantitative analysis of heavy metals in nail samples of drinkers and non-drinkers of river water are shown in Table 2 and 3 respectively. Comparison of iron, copper and zinc concentrations in drinkers and non-drinkers of river water is shown in Table 4.

**Table-2** Heavy metal concentrations in nails of people drinking river water.

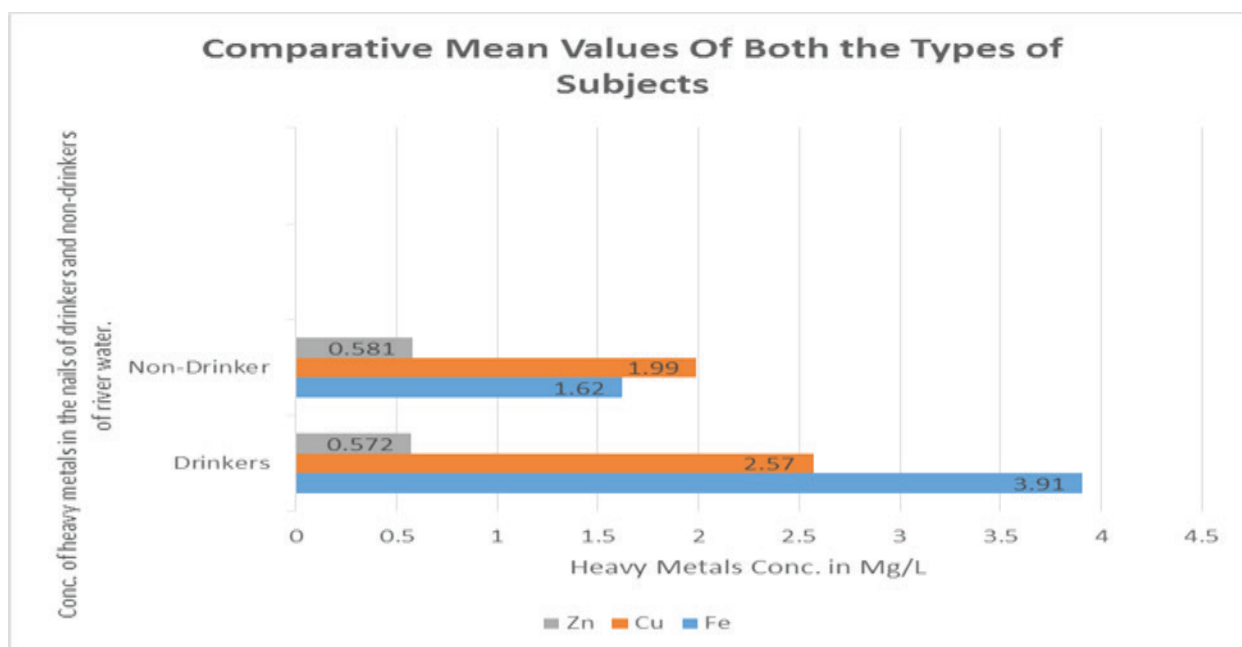
No. of Samples	Fe mg/L	Ni mg/L	Cu mg/L	Cd mg/L	Zn mg/L	Pb mg/L
1	4.5	0	1.9	0	0.46	0
2	3.5	0	2.4	0	0.59	0
3	4.1	0	2.9	0	0.61	0
4	4.3	0	2.9	0	0.61	0
5	4.3	0	2.3	0	0.59	0
6	4.9	0	3.4	0	0.52	0
7	4.3	0	2.3	0	0.59	0
8	4.5	0	1.9	0	0.58	0
9	4.1	0	2.3	0	0.59	0
10	4.9	0	3.4	0	0.58	0

**Table-3 Heavy metal concentrations in nails of non-drinkers of river water.**

No. of Samples	Fe mg/L	Pb mg/L	Zn mg/L	Cd mg/L	Cu mg/L	Ni mg/L
1	1.6	0	0.63	0	1.5	0
2	1.4	0	0.58	0	2.5	0
3	1.3	0	0.55	0	1.1	0
4	1.7	0	0.65	0	1.5	0
5	1	0	0.51	0	2	0
6	2.1	0	0.58	0	2.3	0
7	1.6	0	0.63	0	2.8	0
8	1.5	0	0.62	0	2.3	0
9	2.5	0	0.55	0	2.4	0
10	1.5	0	0.51	0	1.5	0

**Table-4 Comparison of iron, copper and zinc concentrations in drinkers and non-drinkers of river water.**

Nail Samples	IRON (mg/L)		COPPER (mg/L)		ZINC (mg/L)	
	Drinkers	Non-Drinkers	Drinkers	Non-Drinkers	Drinkers	Non-Drinkers
1	4.5	1.6	1.9	1.5	0.46	0.63
2	3.5	1.4	2.4	2.5	0.59	0.58
3	4.1	1.3	2.9	1.1	0.61	0.55
4	4.3	1.7	2.9	1.5	0.61	0.65
5	4.3	1	2.3	2	0.59	0.51
6	4.9	2.1	3.4	2.3	0.52	0.58
7	4.3	1.6	2.3	2.8	0.59	0.63
8	4.5	1.5	1.9	2.3	0.58	0.62
9	4.1	2.5	2.3	2.5	0.59	0.55
10	4.9	1.5	3.4	1.5	0.58	0.51



**Figure-2:** Shows comparison in the mean concentration of heavy metals in the nail samples of drinkers and non-drinkers of river water.

The results of this comparative study showed that heavy metals in the nails of both type of subjects accumulate differently based on exposure. It was observed that highest concentration of Fe (4.9mg/L) and Cu (3.4mg/L) was obtained in the nail sample of people drinking river water whereas highest concentration Zn (0.63mg/L) was obtained in the nail samples of non-drinkers of river water.

The level of Fe and Cu concentration were significantly higher in the people drinking river water when compared to the results of metal concentration of non-drinkers of river water, such differences recorded might be attributed to exposure of the people to heavy metal by drinking the studied area river water. Similar trend was observed for highest Fe and Cu concentration in the river water of studied area i.e. Fe 1.939mg/L > Cu 1.712mg/L.<sup>6,7</sup> This indicates that the concentration of metals in the nail is a function of metal concentration in the work environment or exposure, this was in line with the work of Adulrahman et al.<sup>8</sup> Metabolic activity is absent in nails. Hence it acts as a reliable diagnostic tool for environmental contamination assessment.

Zn concentration was higher in the non-drinkers of river water but concentrations were almost same in both the types of subjects. The reason behind such result may be because in natural surface waters, the concentration of zinc is usually below 10 µg/L, and in groundwater,

10– 40 µg/L. In tap water, the zinc concentration can be much higher as a result of the leaching of zinc from piping and fittings. Drinking-water usually makes a negligible contribution to zinc intake unless high concentrations of zinc occur as a result of corrosion of piping and fittings.<sup>9</sup>

Ni, Cd and Pb showed negative result in both types of subjects. The reason for the negative results of Ni, Cd and Pb concentration in the nail of the people drinking river water might be because of the fact that these metals were not present in high amount in the river i.e. Ni- 0.345±0.0093mg/L, Cd- 0.33±0.0013mg/L and Pb- 0.284±0.0525mg/L which is comparatively very less than the concentration of Fe-1.939±0.0494mg/L and Cu- 1.712mg/L.<sup>6,7</sup> The reason for the negative results of Ni, Cd and Pb concentration in the nail of the people not drinking river water might be because they are not exposed to these heavy metals in daily routine.

## Conclusion

Fe and Cu concentration was significantly high in the nails of people drinking river water and Zn concentration was slightly higher in the nails of non-drinkers of river water whereas negative results were obtained for Pb, Cd and Ni in both the type of subjects.

**Conflict of Interest-** Nil

**Source of Funding-** Self

**Ethical Clearance-** Verbal consent was taken from each person before taking nail clipping from the free margin/distal edge (margo liber) of nail plate.

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