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# Investigation of Heavy Metal Pollution in Karadere Stream (Trabzon, Turkey) By Using Heavy Metal Pollution Index Model

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**Abstract:** This study covers the investigation of heavy metal pollution in Karadere Stream which is located in Trabzon, East-Black Sea Basin. 10 heavy metal parameters (Pb, Zn, Cr, Fe, Cu, Ni, Al, As, B and Ba) were analysed on water samples taken from two stations on Karadere Stream every month, covering the period of February 2017 - July 2017. The results of heavy metal analysis were evaluated according to maximum values given in Water Quality Regulation. The results of the analysis showed that Fe, Cu and Al values were exceeded the limit values for both station. The heavy metal pollution index model was found useful to assess the overall pollution level with respect to heavy metals and the values were found above the critical pollution index value of 100 for both station.
**Keywords:** Heavy metal, Index Model, Karadere Stream

## INTRODUCTION

Water quality is very important for human health and for environment. Fresh water resources are very limited in the world. Many factors such as rapid growth in human population, technological developments, adversely effects the quality of water [1,2]. Various kinds of pollutants can enter water through different ways. Among these pollutants, heavy metals are one of the major contaminants due to their non-degradable properties. They are toxic, can accumulate human body and effects the nervous system. They have also harmful effects in aquatic life [2]. Thus, proper assessment of the water quality according to heavy metal pollution is very important.

Heavy metal pollution index (HPI) is a method of assigning a weightage ($W_i$) for individual heavy metal parameter which shows the composite influence of each heavy metal on the overall quality. The weightage value changes between 0 and 1 and inversely proportional to the limit values given in the regulations. The calculation procedure includes 3 steps:

1. Calculation of unit weightage ($W_i$) which can be taken as inverse of standard limit values ($S_i$)
2. Calculation of sub-indices ($Q_i$) (Eq. 1):

$$Q_i = \sum_{i=1}^{n} \frac{\{M_i(-)I_i\}}{S_i - I_i} * 100 \qquad \text{(Equation 1)}$$

$M_i$ is the monitored value, $I_i$ is the ideal value of the ith parameter in µg/L and n is number of parameters. In this study, the ideal values, $I_i$, was assumed as zero for all element.

3. HPI was calculated by using Eq. 2.

$$HPI = \sum_{i=1}^{n} Q_i W_i \Big/ \sum_{i=1}^{n} W_i \qquad \text{(Equation 2)}$$

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Generally, the critical pollution index value is 100 [1-3].

This study covers the evaluation of water quality of Karadere Stream with respect to its heavy metal concentration by using heavy metal pollution index (HPI). 10 heavy metal parameters; lead (Pb), zinc (Zn), chromium (Cr), iron (Fe), copper (Cu), nickel (Ni), aluminium (Al), arsenic (As), bor (B) and barium (Ba) parameters were analysed and evaluated.

## MATERIAL&METHODS

Karadere Stream is located in Trabzon, East-Black Sea Basin (Figure 1). A yearly average water potential of Karadere Stream is 15.6 $hm^3$ and the flow rate is 434 $m^3 s^{-1}$. The stream is generally used for drinking water, agricultural and also for energy production purposes. Karadere Stream is open to pollution due to human activities (domestic waste waters), agricultural activities (pesticides and fertilizers) and industrial activities [4].


**Figure 1.** Karadere Stream, Trabzon, Turkey (Google Maps)

Water samples were collected from Karadere Stream at two stations every month over the period from February 2017 to July 2017. The samples were collected in 1 L plastic bottles and preserved by adding 1 mL of 1:1 diluted nitric acid (From 65% $HNO_3$, Merck). Bottles were sealed tightly and transported to the DSI Water Analysis Laboratory in accordance with "Standard Methods 1060 Collection and Preservation of Samples" [5].

Heavy metal analyses were carried out according to the EPA 200.8 method by using ICP-MS (Varian, USA) [6].

## RESULTS&DISCUSSIONS

Analysis of 10 heavy metal parameters (Pb, Zn, Cr, Fe, Cu, Ni, Al, As, B and Ba) has been done during experimental period and the minimum, maximum values and standard deviation of analysis results were listed in Table 1.

The results were evaluated according to the maximum values given in Turkish Surface Water Quality Regulation [7] (Table 1). The results represent temporal and spatial variations. It was determined that 3 parameters (Fe, Cu and Al) exceeded the limit values given in the Turkish regulation. Iron and aluminium are among the most abundant elements in Earth's crust. Exposure to high amounts of these elements may cause health problems in human.

**Table 1.** The minimum and maximum values, corresponding maximum values given in Turkish Surface Water Quality Regulation

| | | **Karadere-1** | | | | **Karadere-2** | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Parameters** | **Limit Values (µg/L)** | **Min Value (µg/L)** | **Max Value (µg/L)** | **Average Value (µg/L)** | **Standard Deviation** | **Min Value (µg/L)** | **Max Value (µg/L)** | **Average Value (µg/L)** | **Standard Deviation** |
| Lead (Pb) | 14 | n.d. | 5,07 | 3,76 | 1,58 | n.d. | 13,17 | 5,35 | 4,36 |
| Zinc (Zn) | 231 | n.d. | 318,72 | 65,19 | 24,73 | n.d. | 291,50 | 165,23 | 135,48 |
| Chromium (Cr) | 142 | n.d. | 1,27 | 1,27 | - | n.d. | 1,66 | 1,66 | - |
| Iron (Fe) | 101 | n.d. | 274,73 | 165,70 | 71,47 | n.d. | 2721,14 | 1605,56 | 1270,89 |
| Copper (Cu) | 3,1 | n.d. | 13,27 | 11,77 | 0,96 | n.d. | 22,92 | 16,71 | 5,58 |
| Nickel (Ni) | 34 | n.d. | 6,68 | 3,45 | 1,87 | n.d. | 4,88 | 4,63 | 5,55 |
| Aluminum (Al) | 27 | n.d. | 478,80 | 173,57 | 87,82 | n.d. | 3020,98 | 1779,37 | 1429,80 |
| Arsenic (As) | 53 | n.d. | 1,65 | 1,22 | 0,46 | n.d. | 1,54 | 1,54 | - |
| Bor (B) | 1472 | n.d. | 9,51 | 5,01 | 4,18 | n.d. | 4,10 | 4,10 | - |
| Barium (Ba | 680 | n.d. | 62,86 | 52,04 | 12,82 | n.d. | 133,67 | 92,00 | 39,44 |

n.d. not detected

In order to calculate heavy metal pollution index (HPI), the mean concentrations were calculated. Calculated index values and unit weightage values were listed in Table 2.

The HPI model used in this study is a very useful tool in order to evaluate water quality of surface water with respect to heavy metal pollution. The calculated heavy metal pollution index values were found above critical pollution level, 100, which means both station is polluted with heavy metals. It can be say that HPI model gave reasonable results when compared with individual analysis results which showed that Fe, Al and Cu values above the limit values given in the standard.

## CONCLUSION

Heavy metals are toxic, accumulate in the environment and adversely affect living organisms. The assessment of water quality of Karadere Stream according to heavy metal pollution is studied in this paper. Analysis of 10 parameters (Pb, Zn, Cr, Fe, Cu, Ni, Al, As, B and Ba) were conducted during experimental studies. The results were evaluated according to Water Quality Regulation, 2016 and it was detected that Fe, Cu and Al values were exceeded the limit values given in the standards. The heavy metal pollution index model was applied the obtained experimental results and the values were found above critical pollution level, 100, which means Karadere Stream is polluted with heavy metals.

**Table 2.** HPI calculation for Karadere Stream

| **Heavy metals** | **Mean concentration value ($M_i$) (µg/L)** | **Standard limit value ($S_i$) (µg/L)** | **Unit weightage ($W_i$)** | **Sub-index ($Q_i$)** | **$W_i$*$Q_i$** | **HPI** |
|---|---|---|---|---|---|---|
| **Karadere - 1** | | | | | | |
| Pb | 3,76 | 14 | 0,0714 | 26,82 | 1,9158 | 299 |
| Zn | 65,19 | 231 | 0,0043 | 28,22 | 0,1222 | |
| Cr | 1,27 | 142 | 0,0070 | 0,89 | 0,0063 | |
| Fe | 165,70 | 101 | 0,0099 | 164,06 | 1,6244 | |
| Cu | 11,77 | 3,1 | 0,3226 | 379,74 | 122,4974 | |
| Ni | 3,45 | 34 | 0,0294 | 10,15 | 0,2986 | |
| Al | 173,57 | 27 | 0,0370 | 642,85 | 23,8093 | |
| As | 1,22 | 53 | 0,0189 | 2,30 | 0,0434 | |
| B | 5,01 | 1472 | 0,0007 | 0,34 | 0,0002 | |
| Ba | 52,04 | 680 | 0,0015 | 7,65 | 0,0113 | |
| **Karadere - 2** | | | | | | |
| Pb | 5,35 | 14 | 0,0714 | 38,21 | 2,7296 | 870 |
| Zn | 165,23 | 231 | 0,0043 | 71,53 | 0,3096 | |
| Cr | 1,66 | 142 | 0,0070 | 1,17 | 0,0082 | |
| Fe | 1605,56 | 101 | 0,0099 | 1589,66 | 15,7392 | |
| Cu | 16,71 | 3,1 | 0,3226 | 539,03 | 173,8814 | |
| Ni | 4,63 | 34 | 0,0294 | 13,62 | 0,4005 | |
| Al | 1779,37 | 27 | 0,0370 | 6590,26 | 244,0837 | |
| As | 1,54 | 53 | 0,0189 | 2,91 | 0,0548 | |
| B | 4,10 | 1472 | 0,0007 | 0,28 | 0,0002 | |
| Ba | 92,00 | 680 | 0,0015 | 13,53 | 0,0199 | |

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