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Survey of the effect of dust storms on the water quality of Seimare dam

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ABSTRACT:

Introduction: Lakes and surface waters are sensitive areas that have potential to pollute with different pollutant sources. Pollutants can enter the sea through inlets, drainages and atmospheric deposits. Atmospheric deposits are one of the most critical factors in increasing the pollutants in a lake. Dust storms, through the movement of plankton on the coast, increase some of the nutrients which ultimately cause the eutrophication and create red waves on the coast.

Materials and methods: Particle measurement method is described by Dust fall jar, a standard method for collecting and measuring depositional particles in the air, according to ASTM D1739-98, 2004 standards. In this method, containers with standard size and shape are used. These containers are already installed in the laboratory and finally opened and deployed on suitable sites; so particles can be deposited in it for 30 days and then the particles were weighed. Acid digestion was used to measure heavy metals, and the heavy metals were determined using the ICP device. Information about the area of the lake and the volume of water behind the dam were collected from the Iran Water Resources Management. Excel 2016 was used to perform calculations and plotting graphs.

Results: The results showed that the average dust fall particles around the Seimare dam were 10.85 g / m^2. Month. On average, monthly 306 tons particles enter the dam through the air which increased the concentration of water particles by 0.32 mg / L. These particles increased the Fe and Al concentration in water to140 µg / L, 47.32 µg / L respectively.

Conclusion: Fe had the highest content among the metals and formed a bulk of particles. Then, Al, Ti, Mn, Sn, Mg, K, Cr, Ni, Ba, Ca, Zr, Pb, Sr, V, Cu, Co, Li, Zn, Y, Mo, Tl, La, Be and Cd with the lowest amount, respectively. The results showed that most of the metals had high enrichment factor (EF). This represents the anthropogenic origin of these metals.

Introduction

Studies on oceans' floor sediments suggest that dust storms have occurred over 70 million years ago [1]. Dust storms happen more in the summer and spring, and their occurrence is lower in the autumn and winter. During a dust storm, a strong wind starts to blow, dust and sand rise, air temperature suddenly decreases and air pressure and

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relative humidity increase immediately [2]. Lakes and surface waters are sensitive areas that have potential to contaminate with different sources. Pollutants can enter the sea through inlets, drainages and atmospheric deposits [3]. High concentrations of pollutants can decrease the biodiversity of the lake ecosystem and alter the physical environment around the lake [4]. Atmospheric deposits are one of the most critical factors in increasing the pollutants in a lake [5, 6]. Pollutants and dust in the air are driven by the wind; they combine with each other or with water and fall through wet or dry deposits. Particles that reach Earth's surface can enter nutrients and metals in aquatic ecosystems such as lakes [8]. Sedimentation of sulfates and nitrates increases the acidity of water [9, 10]. Dust storms, through the movement of plankton on the coast, increase some of the nutrients which ultimately cause the eutrophication and create red waves on the coast [11]. Awareness of sedimentary dust sources is remarkable in achieving an adequate level of air quality. To study environmental pollution sources, the receptor model is a very effective tool and, as a result, it is widely used in environmental studies [12]. Many researchers found that Asian dust storms caused by arid or semi-arid areas, such as the deserts of Mongolia, North China, and Kazakhstan, which often occur in the spring, not only have a great impact in northern China, but also can affected the seas of China, especially the Yellow Sea [13].

In recent years, the phenomenon of air pollution and dust storm has created over the country's western provinces and even the capital several times due to the high-pressure system in the southern parts of Iraq and northern Saudi Arabia. The drought in the southern and central parts of Iraq, as well as in the western and northwest of Saudi Arabia, has created the drying of rangelands and turned them into deserts so that these deserts have become the source of dust for entering Iran. Furthermore, the eight-year Iraq war against Iran destroyed many of the palaces of Basra in Iraq and Abadan of Iran that like a filter, it reduced dust storms from the Saudi Arabian desert, as well as it had the preventing role of wind and suspended particles. The construction of 30 dams in Turkey and Syria on the Tigris–Euphrates River led to the drying of the Mesopotamian pond and the creation of a dry area of 500,000 hectares which has increased the intensity of incoming dust. It should be noted that the dust caused due to drought in Khuzestan is one of the sources of dust in western of Iran [14].

Seimare Dam is built at 30 km of the northwest of Dareshahr city in Ilam Province on the Seimare River with about 100 m^3 / s. Seimare River is a boundary separating the provinces of Ilam and Lorestan and is one of the main branches of the Karkheh River [15]. The length of the lake behind the dam is 60 km and its width is 202 m, its area is 63 km^2 and its total volume is 2,473 million m^3 [16]. Since the comprehensive study has not been done on the impact of dust storms on water quality, especially reservoirs of dams, and given the fact that the Seimare dam is one of the main dams of the country, so any information about the amount and type of material entering the reservoirs of dams and its impact on water quality is pretty important. This study was conducted in Ilam province, one of the western provinces of the country, where dust storms generally happen in this province. It is hoped that the results of this study can assist the authorities to function and provide a comprehensive plan to reduce air pollution and decrease its influence on water resources in the west of the country.

Materials and methods

Sampling

Particle measurement method is described by Dust fall jar, a standard method for collecting and measuring depositional particles in the air, according to ASTM D1739-98, 2004 standards. In this method, containers with standard size and shape are used. These containers are already installed in the laboratory and finally opened and deployed on suitable sites; so particles can be deposited in it for 30 days. The containers were eventually closed and returned to the lab. In this method, the results are reported based on g / m^2.month. Containers used are a 150 mm diameter open glass cylinder with a height of 300 mm, which is placed on a tripod so that the span of the sample container was 2 m above the ground. It also had a windshield to increase sampling accuracy [17]. Samples were collected from the first of March to the end of May, 2015, for three months around the Seimare Dam. Because of the high requirements for selecting suitable sampling sites, it was difficult to choose. The criteria for choosing the right site were as follows: near to the water and in an open area, No buildings and structures taller than 1 meter, in a radius of 20 m from the base of the container, Being away from sources of local pollution that can affect the deposition of particulate matter, In addition, access to the site should be comfortable and safe from human and animal access [17].

Tests and chemical analysis

The container was taken to the lab, and 500 ml of deionized water was slowly poured into it at several steps so that all of the dust deposited on the floor and the inner wall of the glass is transferred to the water. To ensure the separation of the entire sediment, a clean flexible skillet was used. To ensure separation of the total sediment, a clean flexible skimmer was used. And then all the contents of the sampling glass were transferred to a 1000 mm container. The liquid containing solids, which was completely mixed, was passed through a paper filter (Watten filter paper 40), its weight was determined using a digital scale of 0.001 g accurately. Then, the filter was placed inside the oven for an hour at 103 to 105 ° C for drying. After an hour, the filter was put in a desiccator for 15 min to collect moisture and weighed by a digital scale, which was recorded as the secondary weight of the filter.

In the next step, according to the instructions given in the ASTM D1739-98, 2004 standard, the solution passed through the filter was transferred into the one-liter container. Then put the container on a plate heater at a temperature below 100 ° C and allow the water to evaporate to about 20 to 50 ml. The remaining liquid was poured into the crucible previously dried and weighed (initial weight of the crucible). The crucible was placed in an oven with the temperature of 103-105 ° C to dry it. After drying the water, the crucible was placed in a desiccator for 15 min to remove moisture. Then the crucible was weighed by the digital scale and recorded as the second weight of it.

Dust fall mass calculations

The tests comprised two steps: measuring the insoluble particles in water (these particles being placed on the filter), and the particles dissolved in water (after passing through the filter, the solution containing these materials, evaporated and dried in the crucible). Therefore, the following information is obtained from experiments and to show the results in g / m^2.month, Eq. (1) is used:

$$DF = \frac{DF_S + DF_{nonS}}{A}$$

F1: initial weight of the filter

F2: Secondary weight of the filter

C1: initial weight of the crucible

C2: Secondary weight of the crucible

A: Container area

D: Container diameter

$DF_{non\ S}$: Mass of insoluble particles in water

DF_S: Mass of soluble particles in water

Determination of heavy metals in sedimentary particles

To determine the heavy metals and pseudo-metals in the particles, the weighed and stored filters were poured into Teflon containers with solvent solids. Then 3 ml of nitric acid, 3 ml of hydrochloric acid and 1 ml of hydrofluoric acid were added to it and were put in the oven for 3-4 h at 150 ° C. After that, it was given 30 min to cool the Teflon containers. Later, the container was placed on a 90 ° C heater to dry completely. Finally, 1 ml of nitric acid and 9 ml of distilled water were added to it, and the resulting solution was passed through a 0.45-Whatman filter. The filtered solution was transferred to a sterile vial and injected into an ICP device for determination of heavy metals [18]. Information about the area of the lake and the volume of water behind the dam were collected from the Iran Water Resources Management. By calculating particles deposited on the lake, as well as dividing it into the amount of water present in the reservoir, particles and heavy metals entering the water through air particles were calculated.

Enrichment factors

Enrichment factors (EF) are good indicators for determining the natural or human origin of heavy metals found in particles [20]. The enrichment factor was calculated using Eq. (2). This formula has already been used in various studies [21, 22]. This calculation is based on the concentration of heavy metals in the particles of dust and earth crust.

$$EF= [(C_X/C_{Ref})_{\text{deposited dust}}]/ [(C_X/C_{Ref})_{\text{Earth's crust}}]$$

In this equation, Cx is the concentration of the element studied, and CRef is the concentration of the reference element [23]. In this study, aluminum was used as a reference element because its contribution to anthropogenic activities could be ignored. EF values are divided into five categories: less than 1 indicates that the element is derived from the earth's crust and its origin is completely normal; Less than 2, very little enrichment; 2-5, medium enrichment;5-20 , significant enrichment, and above 20 show very high enrichment [24]. EF values are classified into five categories: less than 1 indicates that the element is derived from the earth's crust and its origin is completely normal; Less than 2, very little enrichment; 2-5, medium enrichment; 5-20, significant enrichment, and above 20 show very high enrichment [24].

Results and discussion

Concentration of dust fall and its precipitation to the reservoir

Table 1 summarizes the results of the amount of monthly dust along the dam, the dam area, the volume of water behind the dam, the total amount of particles entering the dam, and the increase in the concentration of water particles as a result of the entry of air to water. The results for sedimentary particles around the dam show that the lowest concentration recorded in May (22.22 g / m^2 . month), and the highest concentration recorded in March (17.20 g / m^2 . month). The average dust fall of the air in this quarter was 10.85 g / m^2 . month. Many researchers examined dust fall concentration on a lake in Palestine. Their results showed that the average annual sedimentation rate of these particles was 5.88 g / m^2 . month (The report says 12,000 tons / 170 km^2 / year). In this report, the standard rate of dust fall particles was 20 g / m^2 . month [19].

The total amount of particles entering the reservoir was the highest and equal to 476.32 tons, due to the high concentrations of particles in March, and the lower area of the reservoir in this month than the other months. The high amount of the particles and the high ratio of surface to volume of the reservoir this month increased the concentration of particles in water (0.529 mg / L). In April, the particle concentration was lower than in March and total inlet particles equaled 378.21 tons, which increased the concentration of water particles (0.377 mg / L). In May, the particles entering the reservoir were 64.26 tons, which caused a slight increase in water particles (0.063 mg / L).

Heavy metal concentrations

The amount of heavy metals present in the dust fall particles around the dam is shown in Figs. 1 and 2. Fe with an average of 4683.14 mg / m^2 . month had the highest content among the metals and formed a bulk of particles and Al and Ti were in the next level. Then Mn, Sn, Mg, K, Cr, Ni, Ba, Ca, Zr, Pb, Sr, V, Cu, Co, Li, Zn, Y, Mo, Tl, La, Be and Cd with the lowest amount (0.32 mg / m^2 . month) respectively.

Table 1. Results of the amount of monthly dust along the dam and the increase in the concentration of water particles as a result of the entry of air to water

Month	Dam area (km^2)	Reservoir volume (MCM)	Dust fall (g / m^2 . month)	Total particles entering the reservoir (ton)	Concentration of particles entering the water (mg / L . month)
March	27.68	900.2	17.204	476.321	0.529
April	28.77	1002.14	13.142	378.214	0.377
May	28.87	1012.28	2.225	64.267	0.063
Average	28.44	971.540	10.857	306.268	0.323

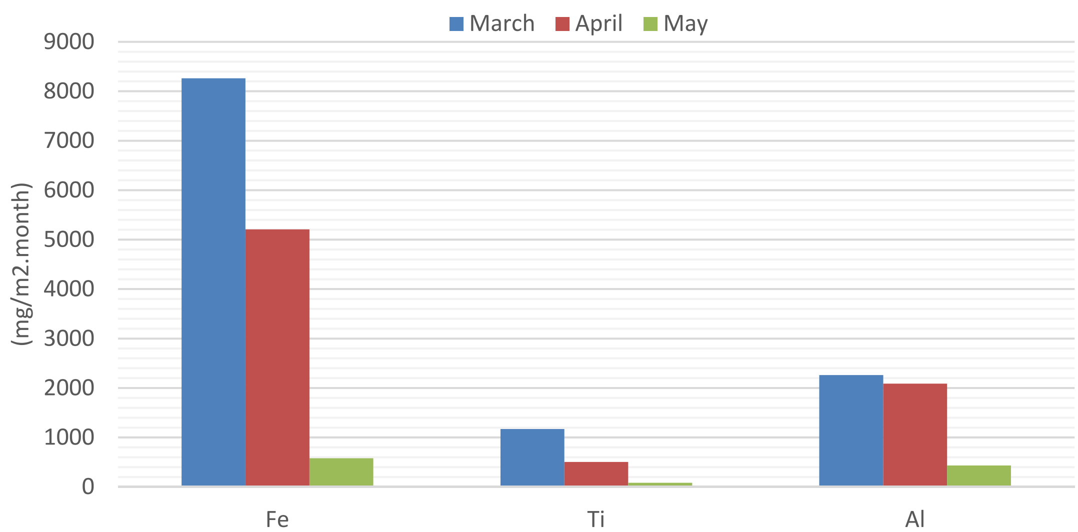

Fig. 1. The amount Al, Fe, Ti in the dust fall around the dam (mg / m^2. month)

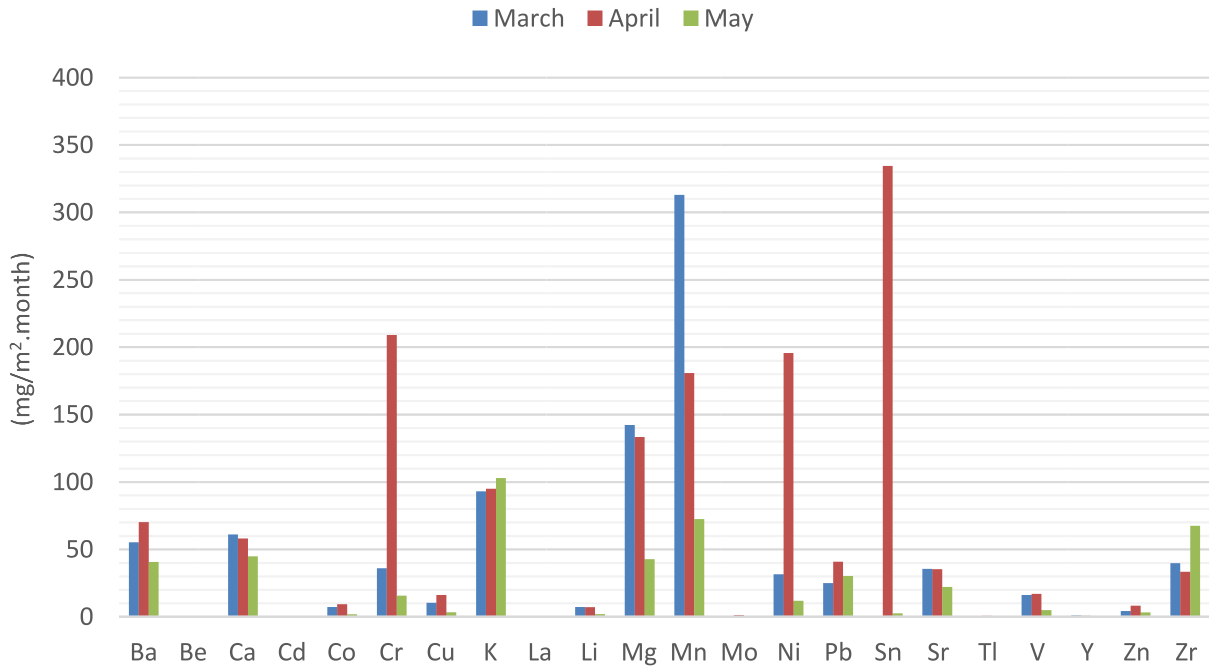

Fig. 2. The amount of heavy metals in the dust fall around the dam (mg / m^2. month)

About 70 % of the particles entering the water were heavy metals, Which, Fe was the most significant of the particles. In Figs. 3, 4 and 5 is shown the percent concentration of heavy metal added to water through the deposition of particles for various months. As can be seen, Fe, Al, and Ti concentrations were relatively high, and other metals had trace concentrations. The metals of Mn, Sn, Mg, K, Cr, Ni, Ba, Ca, Zr, Pb, Sr, V, Cu, Co, Li, Zn, Y, Mo, Tl, La, Be and cd, were classified in a group.

Table 2 shows the concentration of heavy metals entered into water through air particles, expressed in µg /L water, in different months. If these metals enter the water from other sources, the concentration of them in the water can be higher than the standard level. But, if the only source of metals is airborne particles, the concentration of metals in water is less than the standard level of EPA.

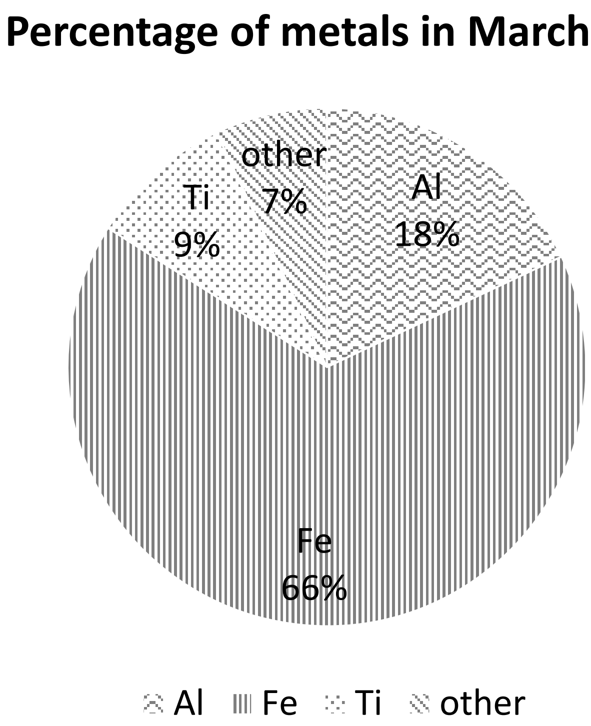

Fig. 3. Comparison of the metals in the water in March

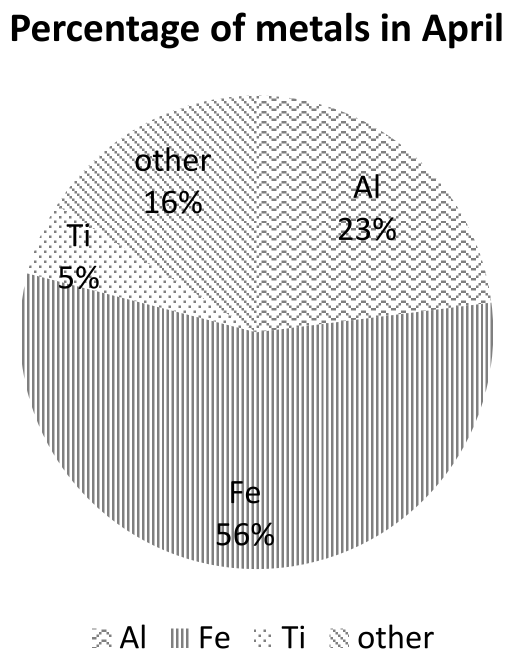

Fig. 4. Comparison of the metals in the water in April

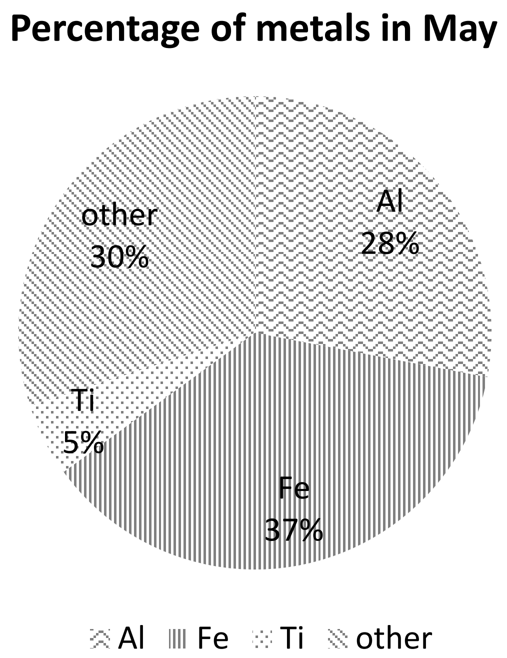

Fig. 5. Comparison of the metals in the water in May

Table 2. The increased rate of concentration of heavy metals in µg / L in the water of the Seymareh dam

Month / Heavy metals	March	April	May	Average
Al	69.61	59.95	12.35	47.3
Ba	1.7	2.02	1.16	1.62
Be	0.02	0.01	0.01	0.012
Cd	0	0.03	0	0.009
Co	0.23	0.27	0.05	0.18
Cr	1.11	6.01	0.45	2.52
Cu	0.32	0.47	0.1	0.29
Fe	254.1	149.51	16.58	140.06
Li	0.23	0.21	0.06	0.16
Mn	9.63	5.19	2.07	5.63
Mo	0.01	0.04	0.02	0.023
Ni	0.97	5.61	0.34	2.3
Pb	0.77	1.17	0.87	0.94
Sn	0	9.6	0.07	4.83
Sr	1.1	1.02	0.63	0.91
Ti	36.07	14.53	2.44	17.68
V	0.5	0.49	0.14	0.38
Zn	0.14	0.24	0.09	0.15

Enrichment factor

The results of the enrichment factor are shown in Fig. 6. The study found that most of the stubborn metals in the water are of human origin. EF was variable for Be and Ba between 5 and 18, which indicates significant enrichment. For Cd it was very variable, in March, EF was less than 2, this means that its origin was natural. However, the EF was188 in April and 24 in May, and it had a completely human origin. The enrichment of the rest of the metals was also remarkable in some cases, and in most cases, it was very high. Most of the metals in April had a much higher enrichment rate than in May and March. Lead also has a very high EF in every three months, which indicates the anthropogenic origin of it.

Conclusion

In this study, the dust falls around the Seimare dam in Ilam and the effect of these particles on the water quality of this dam was investigated. The results showed that the average dust fall particles around the Seimare dam were 10.85 g / m^2 . month. On average, monthly 306 tons particles enter the dam through the air Which increased the concentration of water particles by 0.32 mg / L /month. These particles increased the Fe and Al concentration in water to140 µg /L, 47.32 µg / L respectively. If the metals and elements do not come into the water from other sources and only enter into the water from dustfall, the concentration of these metals is lower than the EPA standard. But if metals come into the water from other sources and metals from airborne particles are also added, metal concentrations are likely to be higher than the standard level.

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Competing interests

The authors confirm that there is no competing interest for this research.

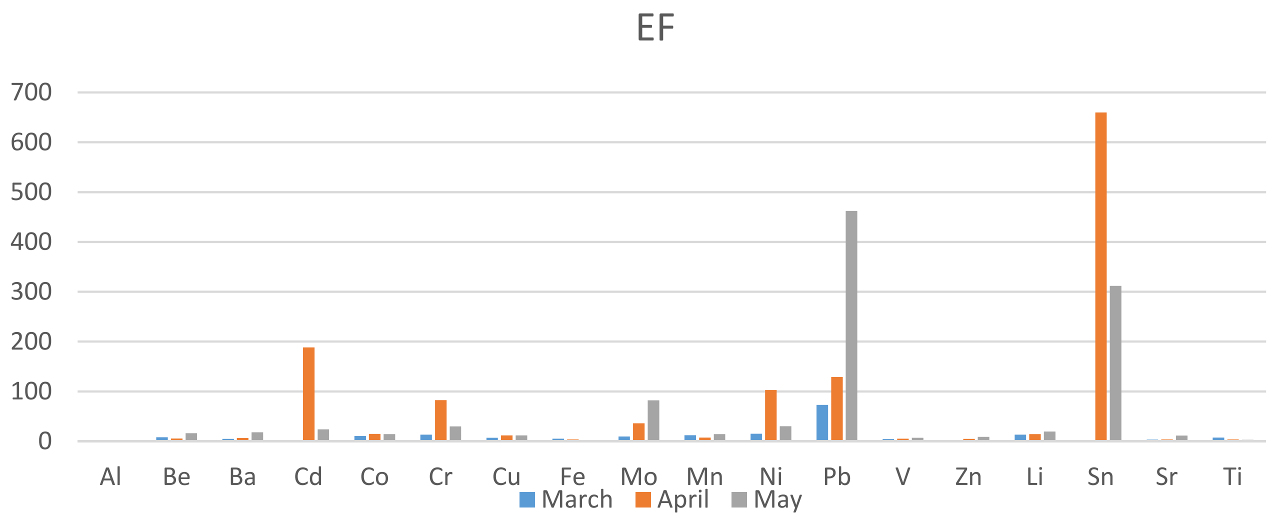

Fig. 6. Heavy metal enrichment factor in air particles around the Seimare Dam in different months

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Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and / or falsification, double publication and / or submission, redundancy, etc.) have been completely observed by the authors.

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