Journal of Physics: Conference Series

PAPER • OPEN ACCESS

Magnetic properties of fishes from rivers near Semarang, Central Java

IOP Conf. Series: Journal of Physics: Conf. Series **983** (2018) 012027 doi:10.1088/1742-6596/983/1/012027

Magnetic properties of fishes from rivers near Semarang, Central Java

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Abstract. Magnetic properties, in the form of magnetic susceptibility (χ) and frequency-dependent susceptibility (χ_{fd}) were measured on scores of samples made of fishes from river nearby Semarang, Central Java. Semarang is one of the major cities in Indonesia, where the river systems are very likely to be contaminated by anthropogenic activities. The objective of this study is to identify the presence of heavy metals in the fishes that will determine the suitability of these fishes for healthy food. The results show that magnetic susceptibility varies from -0.3 to 13.8 × 10^{-8} m^3/kg, while the frequency-dependent susceptibility is less than 3% indicating the predominance of ferromagnetic minerals. Quantitative chemical analyses on four samples show consistently high concentration of Ca, while Fe, Hg, Cu, Pb, Cd, and Ni present a few in some of the samples. This finding shows that the fishes are suitable for the ongoing research on environmental magnetism.

1. Introduction

As a direct sink, Rivers suffer the deposition of various particulates from anthropogenic activities. In areas that have higher concentrations of industrial facilities, the waste can reach several thousands of ton. These particles accumulate in the rivers that fishes live in increased concentration can be easily detected using magnetic measurement [1, 2]. However, the most serious pollutants among these different types are heavy metals, such as Pb, Cd, Cu, and Zn [3, 4].

A positive correlation between magnetic susceptibility and concentration of Zn, Pb, and Cd in Polish topsoil was reported by [3, 5]. Strong correlation has also been found between magnetic susceptibility and concentration of Pb, Cd, Cu, and Zn in urban soils in BeniMellal city (Marroco) [6], in Hangzhou [7], in Wuhan [8], and heavy metal contents from suspended sediments from rivers in Semarang [9]. The significant correlations have also been found between the abundance of certain elements with AMS parameters so the magnetic parameters have a good chance to be used as predictors for major elements composition in igneous rocks [10]. In the present research we conduct detailed magnetic susceptibility measurement and chemical analyses of fishes on Kanal Barat rivers Semarang, Central Java, which is where the river is indicated by pollution.

2. Methods

2.1.Sampling

We choose four samples of the fishes, which are: Tilapia fish (*Oreochromis mossambicus*), Catfish (*Clarias batrachus*),Shrimp fish (Crustaceae) and Cattle fish (Plecostomus). The kind of sampling figures are presented in Table 1. A total of 15 samples were measured for magnetic susceptibility, 8 samples were collected at each sampling sites. And only 7 samples at each sampling sites in Kanal Barat like that in Figure 1.

Table 1: The types of fishes

No	Name of Fish	Photo Image
1	Tilapia fish	
2	Catfish	
3	Shrimp fish	
4	Cattle fish	

Figure 1*:* Samples preparation

2.2 Magnetic Measurement

Magnetic measurement was completed in Rock Magnetism Laboratory of University State of Malang, Indonesia. Magnetic susceptibility at dual frequency (470 and 4700Hz) was measured using a Bartington MS2B dual frequency sensor. The values are expressed as mass susceptibility χ_{lf} and χ_{hf}, respective. Frequency dependent susceptibilitywas expressedas a percentage χ_{fd}:

$$\chi_{fd} = \frac{\chi_{lf} - \chi_{hf}}{\chi_{lf}} x100\% \quad (1)$$

Where: χ_{lf} is the low-frequency magnetic susceptibility and χ_{hf} is the high-frequency magnetic susceptibility.

2.3. Heavy Metal Analysis

A quantitative chemical analysis is done for one representative sample in Chemical Laboratory of State University of Semarang, Indonesia. Concentration of heavy metals, such as Zn, Fe, Hg, Cu, Pb, Cd, and Ni, etc. were determined using SEM_EDX.

3. Result and Discussion

3.1. Magnetic *properties*

Magnetic minerals of suspended sediment in the rivers near Semarang may be either inherited from the parent rocks (lithogenic origin), formed during pedogenesisand/or may stem from anthropogenic activities (secondary ferromagnetic material) [11]. To find magnetic criteria we plotted all magnetic susceptibility data of the fishes in Figure 2.

The plotting of magnetic dependent susceptibility versus magnetic susceptibility analysis shows that all samples predominance of ferromagnetic minerals (frequency-dependent susceptibility is less than 3%), but the catfish do not show these symptoms. It indicates that catfish have the special immunity on their body from heavy metal.

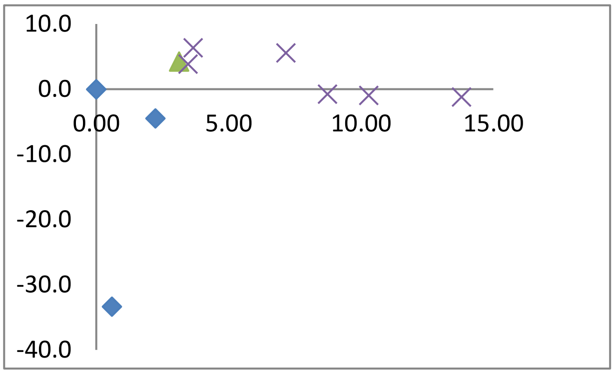

Figure 2*:* Plot magnetic frequency-dependent susceptibility versus magnetic susceptibility

The magnetic susceptibility varies from -0.3 to 13.8 × 10^{-8} m^3/kg, while the frequency-dependent susceptibility is less than 3% indicating the predominance of ferromagnetic minerals. Especial for Catfish, the negative in both low and high-frequency susceptibility are point to show the diamagnetic minerals.

Table 2. Frequency-dependent susceptibility

Sample	χhf	χlf	χfd
Tilapia fish 1	2.33	2.23	-4.48
Tilapia fish 2	0	0	-
Tilapia fish 3	0.8	0.6	-33.33
Tilapia fish 4	0.07	0	-
Catfish 1	-0.23	-0.43	46.51
Catfish 2	-0.3	-0.23	-30.43
Catfish 3	-0.27	-0.13	-107.69
Catfish 4	-0.07	-0.53	86.79
Shrimpfish	3	3.13	4.15
Cattle fish 1	10.4	10.3	-0.97
Cattle fish 2	13.97	13.8	-1.23
Cattle fish 3	6.77	7.17	5.58
Cattle fish 4	8.8	8.73	-0.80
Cattle fish 5	3.33	3.47	4.03
Cattle fish 6	3.43	3.67	6.54

Table 3. A quantitative AAS of catfish

No	Heavy Metal	W (%)
1	Pb	0.0200
2	Cu	0.0220
3	Fe	1.9120
4	Ni	0.1190
5	Co	Nd

3.2. Heavy metal concentrations

A quantitative chemical analysis with AAS is summarized in Table 2, for catfish's samples show consistently in concentration of Fe, Ni, Cu, Pb, while Co is not detected. Furthermore, that is indicated to analyze another sample by SEM-EDX.

A concentration of heavy metals, such as Mn, Fe, Hg, Cu, Pb, Cr, and Ni, etc. were determined using SEM-EDX. The result of this analysis is shown in Table 3. The most percentage of heavy metal is Ca (Table 4).

Table 4. A quantitative chemical analyses

Heavy Metal	W (%)		
	Tilapia fish	Shrimpfish	Cattle fish
Mg	1.82	3.21	2.73
Ca	9.63	16.93	14.82
Ti	0.87	1.83	1.67
Cr	0.29	0.9	0.62
Mn	0.21	0.57	0.3
Fe	0.33	0.81	0.6
Co	0.27	0.51	0.39
Ni	0.24	0.43	0.27
Cu	0.3	0.49	0.37
Zn	0.32	0.7	0.67
Ag		6.8	4.38
Pt	1.04	2.59	1.8
Hg	1.72	3.01	3.51
Pb	2.92	4.7	4.83

Figure 3 shows the mapping of SEM crystal structure of Tilapia fish (a), Shrimp fish (b) and Cattle fish (c).

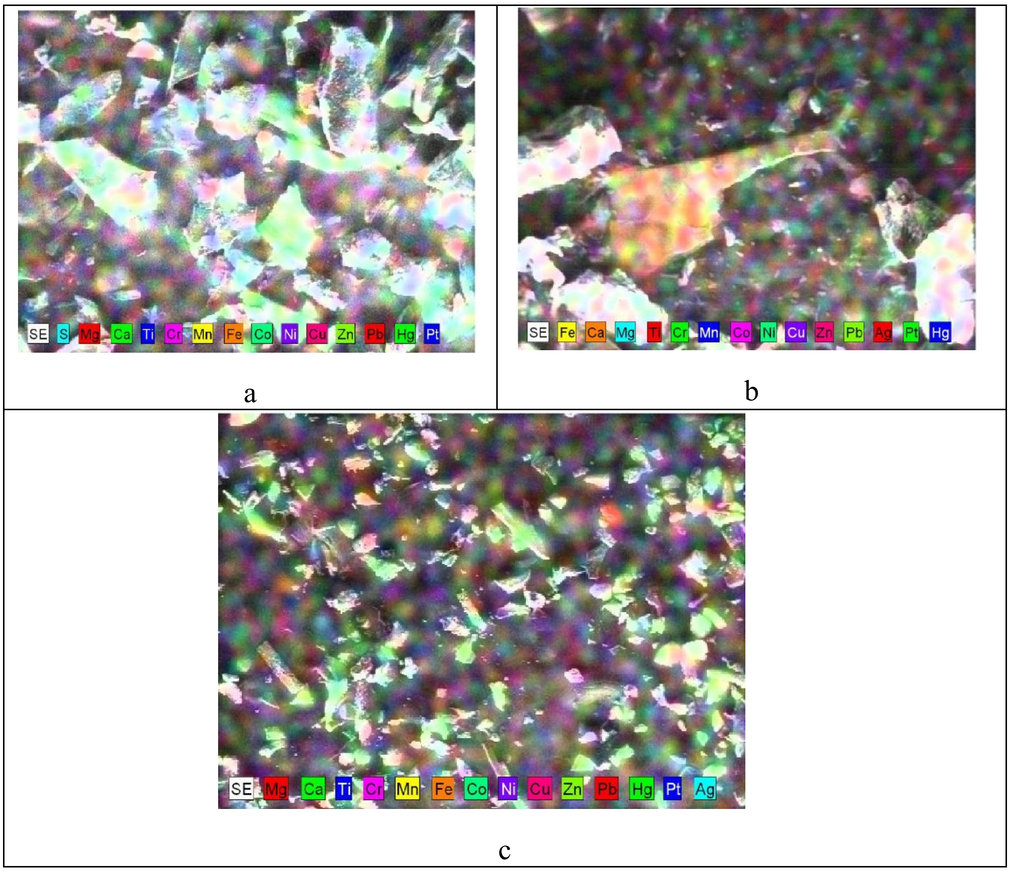

Figure 3. SEM of (a) Tilapia fish, (b) Shrimpfish and (c) Cattle fish

3.3. Correlations between magnetic susceptibility and heavy metals

Generally, magnetic measurements as tool for evaluating pollutions are based on two reasons. First, the magnetic parameter (e.g. magnetic susceptibility) of fishes can be measured. Secondly, magnetic susceptibility have significant correlations with the pollutants. In the present research, the range of magnetic susceptibility are -0.3 to 13.8 (10^{-8} m^3/kg), while the frequency-dependent susceptibility is less than 3% indicating the predominance of ferromagnetic minerals. In addition, the magnetic susceptibility of fishes significantly correlates to concentration of heavy metals according to the previous research [12]. These results can be confirmed that magnetic susceptibility measurement can be used as proxies to the fishes in the rivers near Semarang, Central Java of heavy metals contamination.

4. Conclusions

The magnetic susceptibility measurement are performed on 7 samples from Kaligarangriver in Semarang, Central Java. The results show that magnetic susceptibility varies from -0.3 to 13.8 × 10^{-8} m^3/kg, while the frequency-dependent susceptibility is less than 3% indicating the predominance of ferromagnetic minerals. Quantitative chemical analyses on four samples show consistently high concentration of Ca, while Fe, Ag, Cu, Pb, Co, and Ni present only in some of the samples. This finding shows that the fish are suitable for the ongoing research on environmental magnetism.

Acknowledgements

This research was supported financially by a research grant from The Ministry of National Education in the form of *HIBAH BERSAING* (No. 1.14.5/PPK.3.1/2013).

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