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POSTRIZATION system to reduce metal levels and increase the pH of pit water active tin mining

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Abstrak. The pits left by unconventional tin miners in Bangka Belitung have formed a kind of water reservoir usually used for consumption when there is a drought or scarcity of clean water. This pit water has been contaminated with heavy metals and has a low pH, making it unfit for consumption. Therefore, this study aims to test the POSTRIZATION system that has been developed to increase pH and reduce heavy metal levels so that the water quality becomes fit for consumption. Increasing the pH and decreasing the metal content is carried out through 3 stages: composting, filtration, and distillation. The water sample came from one of the active mining pits in Baturusa, Bangka Regency. The pH level and metal content were measured before and after treatment. The pH level of the water was measured using a pH meter, and the metal content was measured using an Atomic Absorption Spectrometer (AAS). Changes in pH and metal content were calculated using the percentage technique. The POSTRIZATION results showed that the pH of the water increased to 7.6, and the metal content decreased by more than 93%. So, the POSTRIZATION system effectively restores the quality of pit water to fit for consumption. This, directly or indirectly, can prevent people from getting various diseases due to consuming water contaminated with heavy metals.

Keywords: pit water, Heavy metals, pH, Postrisasi

I. Introduction

In Indonesia, Bangka Belitung is one of the largest tin-producing areas [1], [2]. Tin is a type of metal in the precious minerals category, so it has economic value in the world community, including in Indonesia. Its high economic value has caused many people to dig the land to mine tin. This mining activity has occurred since the Dutch colonial era [3]. The majority of the people's tin mining process is still unconventional. After unconventional mining activities are over, people generally just let their land go. This former tin mining area is called under. The pits that are formed are not closed again by the people who are digging, so they become open pits that can be filled with water during the rainy season. Over time, the kolong will become a water source [2].

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During the dry season, several areas in Bangka Belitung experience drought and scarcity of clean water. Therefore, most people use pit water as a substitute for clean water for their daily needs, for example: for drinking, bathing, washing, and using the toilet [4]. Even though research results have shown, that pit water has been contaminated with heavy metals, such as iron (Fe), lead (Pb), manganese (Mn), zinc (Zn), copper (Cu), Cadmium (Cd), and several other metals which generated from the mining process [2], [5], [6]. Even the amount of heavy metal content exceeds the water quality standard. In addition, the result of mining is the reduction of nutrients which causes a decrease in soil fertility [7].

Heavy metals are a group of metallic elements with a density greater than 5 gr/cm^3. At a certain level, it becomes toxic and very dangerous for living things. A large amount of heavy metal content causes the pH of the pit water to have a high level of acidity [8]. The pH in the water under the test is less than seven, so it is acidic [9]. Water with high acidity can be harmful to the body.

The community's activity of consuming pit water contaminated with heavy metals cannot be allowed to continue because it will affect the decline in health. Various studies have reported the negative effects that occur as a result of consuming food or drink that has been contaminated with heavy metals [10]–[12]. Various attempts have been made to reclaim former tin mines to return to their original state, for example, by improving physical, chemical, and biological properties [7], [13]. However, the reclamation effort still leaves several problems. For example, the quality of pit water still contains heavy metals. Therefore, it is necessary to find a solution to reduce the levels of heavy metals in the pit water.

A decrease in heavy metal levels can occur naturally in pits over 20 years old or with access to rivers or the sea [2]. However, human intervention efforts also need to be carried out to accelerate the process of reducing heavy metal levels so that they can be consumed relatively more quickly. Various efforts have been made to reduce the heavy metals in pit water. For example, (1) Planting water hyacinth to absorb Pb and Cd [6], (2) Using compost to minimize lead (Pb) content [14]. However, these efforts only reduce the levels of one or two heavy metals in pit water. Therefore, this study aims to reduce pH and heavy metal levels through a system called POSTRIZATION. The POSTRIZATION system is a layered metal reduction system through composting, filtering/filtration, and distillation processes. The results of POSTRIZATION show an increase in the quality of the raw water quality so that it is suitable for consumption.

II. Method

This research includes the type of experimental research. The experiment was carried out at the Science Laboratory of SMKN 1 Sungailiat and the Laboratory of the Environmental Agency of the Bangka Belitung Islands Province. The tools and materials used in this study are summarized in Table 1. The arrangement of the tools is shown in Figure 1. The process of reducing metal content follows the flowchart in Figure 2.

The initial stage was taking water samples under one of the active mining pits in Baturusa, Bangka Regency. After that, the second stage was carried out, namely the initial testing of metal content and the pH of the pit water. The third stage is to carry out the composting process. Pit water is put into a gallon tap. Then it is mixed with organic compost, consisting of roasted husks, cocopeat, ferns, animal dung, and poor sand. The ratio between pit water and organic compost is 2.4: 1. Pit water mixed with organic compost is soaked and given aeration for 1 X 24 hours. The fourth stage is to carry out the filtration process.

The filtration process uses a PVC pipe filled with natural materials, including zeolite, limestone, beach sand, palm fiber, and cotton. The amount of zeolite in a 500 ml beaker. The amount of limestone in a 500 ml beaker. Amount of beach sand in a 1000 ml beaker. The amount of palm fiber in a beaker measuring 500 ml and five pieces of cotton. Water from the composting process flows into a pipe. The results of the filtration are accommodated in an electric kettle. After passing through the filtration process in the fourth stage, proceed to the fifth stage, namely the distillation process. The filtered water reservoir is an electric kettle. Electric kettle modified to vacuum air for use in the distillation process. The electric kettle is connected with wires and terminals for heating. The water vapor from heating is collected in a beaker glass. Under the beaker glass are ice cubes of water, so the water vapor becomes water. The water produced from the distillation process is pure. The final stage is to test the metal content and pH of the water resulting from composting, filtration, and distillation. The pH test used a pH meter, and the metal content test was carried out using AAS.

Table 1. Tools and materials for reducing pH and heavy metal levels in pit water

No.	Material	Tools
1	Gallons of tap water	Pit water
2	aerators	Compost
3	Electrical cable terminals	Zeolite stone
4	Beaker glass	Limestone
5	derigen	Sand
6	PH meter	Fibers
7	Pipe	Cotton
8	Electric kettle	Ice
9	Atomic Absorption Spectrometer (AAS)	
10	Bottle	

a. Side view b. Front view

Figure 1. POSTRIZATION system Experimental procedure

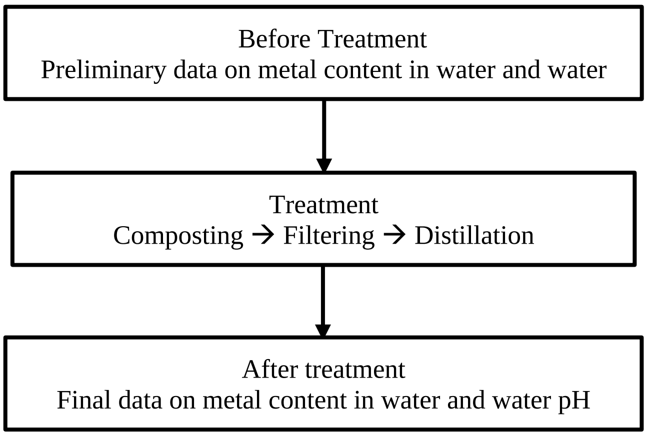

Figure 2. Stages of reducing pH and heavy metal content in pit water

III. Results and Discussion

After the sampling process, the sample was tested for pH, and the initial content was then treated and tested for pH and final content using an Atomic Absorption Spectrometer (AAS). The results of the pH and content tests are presented in Table 2. Then the results of calculating changes in the pH value and metal content are shown in Table 3.

Table 2. pH test results and metal content in pit water before and after treatment.

Treatment		pH	Metal Content		
			Fe (mg/l)	Mn (mg/l)	Zn (mg/l)
Before Treatment		3.2	0.5543	1.0500	0.0900
After Treatment	Composting	6.6	0.0466	1.0123	0.0109
	Filtration	5.8	0.0184	1.5197	0.0980
	Distillation	7.6	0.0165	0.0055	0.0063

Table 3. Changes in pH value and metal content

Metal Content	After Treatment					
	Composting		Filtration		Distillation	
	Content	Annotation	Content	Annotation	Content	Annotation
pH	3.4	Increase	2.6	Increase	4.4	Increase
Fe metal	-91.59%	Decrease	-96.68%	Decrease	-97.02%	Decrease
Mn metal	-3.59%	Decrease	44.73%	Increase	-99.48%	Decrease
Zn metal	-87.89%	Decrease	8.89%	Increase	-93.00%	Decrease

Based on the data in Table 3, it was identified that there was a decrease in the metal iron content (Fe) in each POSTRIZATION stage. The decrease was very significant, exceeding 91%. For zinc metal (Zn), when composting, the content decreased by 87.89%. At the time of filtration rose again but was very small, namely 8.88%. Whereas during the distillation process, it fell back significantly by 93%. Manganese (Mn) metal during composting decreased by 3.59%. At the time of filtration rose again but was less significant at 44.73%. Whereas at the time of distillation, it fell back significantly by 99.48%. So the metal content until the end of the POSTRIZATION stage is effectively reduced by ≥ 93%. This means that the metal content in the final water product is very small.

In composting, all metal content has decreased because organic materials in compost can bind heavy metals [15]. The metal bonding process can be through cation exchange, chelate formation, or electrostatic bonding. So the metal is difficult to be free. In addition, aeration is carried out for 1 x 24 hours in composting. This aeration makes the under-water oxidation process run effectively [16]. Oxidation with air can reduce metal content. This is to the results of Batara et al. [17], who explained that aeration could reduce the concentration of dissolved iron and manganese.

The filtration stage uses natural materials that can adsorb heavy metals like zeolite. So that the levels of iron metal (Fe) can decrease. However, manganese (Mn) in filtration has a rather significant increase. According to Atmoko [18], limestone contains manganese metal (Mn) in the form of rhodochrosite compounds ($MnCO_3$). In distillation, there is a significant reduction of all metals because metals have a high boiling point. It will be difficult to evaporate and boil at temperatures below 200 ^oC. The water has evaporated and boiled, while the metal will remain in the electric kettle.

Based on the data in Table 3, it was identified that the pH of the water before treatment was 3.2. This pH is very low and has a high degree of acidity. After treatment, in each POSTRIZATION stage, the pH of the water has increased. The composting stage increased by 3.4; the filtration rate increased by 2.6, while the distillation stage increased by 4.4 so that each step is effective for raising the pH of the water. The final pH of water is 7.6, meaning that the pH is neutral towards alkaline [19]. This water pH follows the Environmental Protection Agency (EPA) recommendations in the United States, which states that a good drinking water pH standard is between 6.5 and 8.5.

In the composting stage, it is effective to increase the pH because the pit water is mixed with organic materials from the compost, which are neutral and tend to become alkaline. Especially organic matter from roasted husks. There are so many nutrients in roasted husks that the pH is quite high, between 8.5 and 9.0. In addition, heavy metals, especially iron (Fe) and zinc (Zn), in the pit water have decreased significantly. This reduction in metal content reduces the acidity of the pit water.

In the filtration stage, it is also effective in raising the pH. Many research results explain that natural ingredients such as zeolite stone, limestone, sand, and palm fiber are very effective in raising the pH of water. In addition, the use of zeolite stone can adsorb heavy metals. So it can reduce the acidity of the water under it. In distillation, it can produce water whose pH is good for drinking because it is pure. This water $\geq$ 93% successfully reduced levels of heavy metals. This metal decrease occurs because it has a high boiling point, so that it will be left in the electric kettle during the distillation process. Other impurities will also be left in the electric kettle and cannot get into the water vapor. Likewise, germs will die through the process of boiling water.

IV. Conclusion

Based on the results of the research that has been done, it is obtained a pattern of increasing the pH of the water and decreasing the levels of metals in the pit water during the composting, filtration, and distillation stages of the POSTRIZATION system. The final water pH level reaches 7.6, while the final metal content is significantly reduced by more than 93%. So, the POSTRIZATION process effectively restored the quality of kolong water to fit for consumption.

The POSTRIZATION system has significantly restored water quality to fit for consumption. However, the POSTRIZATION process still needs to be integrated with the remineralization system for pit water to increase its quality for consumption. Therefore, we recommend that future research develop a similar tool integrated with the remineralization system.

References

[1] S. H. Syachroni, Y. Rosianty, and G. S. Samsuri, "Daya Tumbuh Tanaman Pionir pada Area Bekas Tambang Timah di Kecamatan Bakam, Provinsi Bangka Belitung," *Sylva J. Ilmu-ilmu Kehutan.*, vol. 7, no. 2, pp. 78–97, Apr. 2019, doi: 10.32502/sylva.v7i2.1544.

[2] A. Meyzilia, "Pemanfaatan Air Kolong Bekas Tambang Timah sebagai Penambah Sumber Air Tanah Menggunakan Lubang Kompos di Bangka Belitung," *J. Pendidik. Ilmu Sos.*, vol. 27, no. 1, pp. 22–30, 2018, doi: 10.21082/jsdl.v12n2.2018.73-82

[3] Asmarhansyah and R. Hasan, "Reklamasi Lahan Bekas Tambang Timah Berpotensi sebagai Lahan Pertanian di Kepulauan Bangka Belitung," *J. Sumberd. Lahan*, vol. 12, no. 2, pp. 73–82, 2018.

[4] R. Nursahidin, R. Y. S., F. R. A., W. Krisno, and G. Guskarnali, "Filtrasi Air Kolong Secara Sederhana di Pondok Pesantren At-Toybah," in *Proceedings of National Colloquium Research and Community Service*, 2021, pp. 185–187, [Online]. Available: https://www.journal.ubb.ac.id/index.php/snppm/article/view/2746.

[5] H. Wahyuni, S. B. Sasongko, and D. P. Sasongko, "Kandungan Logam Berat pada Air, Sedimen dan Plankton di Daerah Penambangan Masyarakat Desa Batu Belubang Kabupaten Bangka Tengah," in *Prosiding Seminar Nasional Pengelolaan Sumberdaya Alam dan Lingkungan*, 2013, pp. 489–494.

[6] Meyzilia, Arvina, and Darsiharjo, "Pemanfaatan Kolong Bekas Galian Tambang Timah untuk Budidaya Eceng Gondok di Provinsi Kepualauan Bangka Belitung," *J. Gea*, vol. 17, no. 2, pp. 153–158, 2017.

[7] I. Hamid, S. J. Priatna, and A. Hermawan, "Karakteristik Beberapa Sifat Fisika dan Kimia Tanah pada Lahan Bekas Tambang Timah," *J. Penelit. Sains*, vol. 19, no. 1, pp. 23–31, 2017, doi: 10.56064/jps.v19i1.8.

[8] M. Mentari, U. Umroh, and K. Kurniawan, "Pengaruh Aktivitas Penambangan Timah Terhadap Kualitas Air di Sungai Baturusa Kabupaten Bangka," *Akuatik J. Sumberd. Perair.*, vol. 11, no. 2, pp. 23–30, 2018, [Online]. Available: https://journal.ubb.ac.id/index.php/akuatik/article/view/240.

[9] A. R. Zulfahmi *et al.*, "Influence of Amang (Tin Tailing) on Geotechnical Properties of Clay Soil," *Sains Malaysiana*, vol. 41, no. 3, pp. 303–312, 2012.

[10] C. Rahma, I. Mulyani, and S. S, "Studi Literatur; Analisis Kadar Logam Berat Pada Susu Kental Manis Kemasan Kaleng," *J. Teknol. Pengolah. Pertan.*, vol. 3, no. 2, pp. 22–26, 2021, [Online]. Available: http://jurnal.utu.ac.id/jtpp/article/view/4625.

[11] E. R. Dewi, "Analisis Cemaran Logam Berat Arsen, Timbal, Dan Merkuri Pada Makanan di Wilayah Kota Surabaya

dan Kabupaten Sidoarjo Jawa Timur," *J. Ilmu Kesehat. Masy.*, vol. 18, no. 1, pp. 1–9, 2022, doi: 10.19184/ikesma.v18i1.20529.

[12] Y. Ardillah, "Faktor Risiko Kandungan Timbal di dalam Darah," *J. Ilmu Kesehat. Masy.*, vol. 7, no. 3, pp. 150–155, Nov. 2016, doi: 10.26553/jikm.2016.7.3.150-155.

[13] R. Gunawan, Nurkhamim, and R. F. Izza, "Overview Metode Perencanaan Pengelolaan Lahan Bekas Penambangan," in *Prosiding Seminar Nasional ReTII ke-16*, 2021, pp. 345–350, [Online]. Available: https://journal.itny.ac.id/index.php/ReTII/article/view/2700.

[14] E. Prasetiyono, "Kemampuan Kompos dalam Menurunkan Kandungan logam Berat Timbal (Pb) pada Media Budidaya Ikan.," *J. Akuatika*, vol. VI, no. 1, pp. 21–29, 2015.

[15] H. Kurniahu, A. Rahmawati, Sriwulan, and R. Andriani, "Uji Potensi Bahan Penurun Kandungan Logam Berat Pb Pada Bahan Baku Kompos Dari Sampah Kertas Bertinta," *J. Pembelajaran Dan Biol. Nukl.*, vol. 8, no. 2, pp. 345–354, 2022, doi: 10.36987/jpbn.v8i2.2799.

[16] H. Sintiya, E. Prasetiyono, and E. Bidayani, "Peningkatan pH air asam dengan kompos daun ubi kasesa (Manihot sp.) untuk kegiatan akuakultur," *Bioma J. Ilm. Biol.*, vol. 10, no. 1, pp. 113–128, Mar. 2021, doi: 10.26877/bioma.v10i1.6310.

[17] Batara, Kapri, B. Zaman, and W. Oktiawa, "Pengaruh Debit Udara dan Waktu Aerasi Tehadap Efisiensi Penurunan Besi dan Mangan Menggunakan Diffuser Aerator pada Air Tanah," Diponegoro University, 2017.

[18] D. D. Atmoko, A. D. Titisari, and A. Idrus, "Mineralogi Dan Geokimia Batugamping Merah Ponjong, Gunungkidul, Daerah Istimewa Yogyakarta - Indonesia," *J. Ris. Geol. dan Pertamb.*, vol. 26, no. 1, p. 55, Jun. 2016, doi: 10.14203/risetgeotam2016.v26.269.

[19] M. R. Setiawati, "Peningkatan Kandungan N Dan P Tanah Serta Hasil Padi Sawah Akibat Aplikasi Azolla pinnata Dan Pupuk Hayati Azotobacter chroococcum Dan Pseudomonas cepaceae," *Agrologia*, vol. 3, no. 1, Feb. 2018, doi: 10.30598/a.v3i1.257.