

ACCOALTIC: Bottom loading dispenser through raw water source Kuantan River polluted Hg from unlicensed gold mining activity

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ABSTRACT

Unlicensed gold mining activities are still a polemic in the people of Kuantan Singingi Regency, starting from 2006 until now. Kuantan River water has a turbidity of 72.42 NTU, a concentration of 0.0325 mg/l Hg, and a bacterial count of 410 CFU/100 ml. Eventhough, Kuantan River water is the main source of raw water used by UPTD PAB with 3,727 active customers. Until now, water treatment at UPTD still uses alum as a purifier without laboratory-scale analysis. The purpose of this study is to analyze the effectiveness of ACCOALTIC's working principles in the Kuantan River raw water purification process and explain the results of the development of ACCOALTIC bottom loading dispenser. The study was conducted in quantitative experiments. ACCOALTIC uses the working principle of 3 filtration tanks, namely purification & coagulation, adsorption, and disinfection. Test parameters using a turbidity meter get an average value of 5 tests per sample after treatment of 0.1 NTU. The decline occurs due to the nature of $Al_2(SO_4)_3$ contains aluminum sulfate. In the XRD test of Hg absorption, there is a peak in the X-ray intensity coordinates (a.u.) which indicates the presence of Hg. SSA testing found a decrease in Hg concentration by 77.21%. The number of *E. coli* bacteria was 410 (before treatment) and 2 (before treatment) in CTU/100 mL units, hence the % value decreased by 99.51% while the development of ACCOALTIC is carried out in the form of bottom loading dispensers.

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1. INTRODUCTION

Unlicensed gold mining activities (UGMA) which took place from 2006-now are still a polemic in the people of Kuantan Singingi Regency. The amalgamation process that produces Hg waste is discharged into the river water environment without any filtration. As a result, Kuantan River water is contaminated with Hg. This is evident from the water content of the Kuantan River. Kuantan River water is brownish muddy, turbidity 72.42 NTU, 0.0316 mg/l Hg [1], contains *E. coli* bacteria of 410 CFU/100 ml. Similar results were also obtained in another study which stated that the Hg concentration of Kuantan River water was 0.0325 mg/l [2]. This means that Kuantan River water has been polluted from its physical, chemical, and biological parameters.

Good water standards have been explained through the Regulation of the Minister of Health of the Republic of Indonesia. Physical water meter for sanitary hygiene purposes for indoor and outdoor

is odorless, tasteless, turbidity worth 25 NTU, air temperature ± 3 , color 50 TCU, total coliform is 50 CFU/100 ml and contains no E.Coli (in CFU/100 ml units). While chemically, quality standards are seen from the parameters in mg / l units, namely pH 6.5 – 8.5, iron 1, fluoride 1.5, hardness CaCO_3 500, Manganese 0.5, Nitrate 10, Nitrite 1, Cyanide 0.1, Detergent 0.05, Total pesticide 0.1, Mercury 0.001, Arsenic 0.05, Cadmium 0.005, Chromium (valence 6) 0.05, Selenium 0.01, Zinc 15, Sulfate 400, Lead 0.05, Benzene 0.01, and organic substances (KMnO_4) 10. When compared, the value of the water content of the Kuantan River is far from feasible to meet the needs of the people of Kuantan Singingi Regency.

In fact, Kuantan River water is the main source of raw water used by UPTD Clean Water Provider of Kuantan Singingi Regency, especially the Teluk Kuantan Unit with 3,727 active customers. The results of UPTD processing are distributed to meet the needs of violations, such as bathing, washing and cooking.

Unfortunately, technological limitations make UPTD unable to process Kuantan River water to be clear considering the condition of the river water which is quite turbid and dense [3]. Until now, water treatment at UPTD still uses alum as a purifier without laboratory scale analysis. There has been no intensive effort in reducing Hg levels in the water. This means that the water distributed and consumed by the 3,727 active customers is water that can harm health. Therefore, further technological development and intensive efforts are needed so that water can again meet the quality standards that have been set.

Some efforts that have been found to address Hg waste are by using plant media and magnetic carbon. The Carbon which is added magnetite compound namely Fe_3O_4 can have heavy metal binding strength. In a study, it can be proven if magnetic carbon material can bind Hg to a maximum of 0.01 mg Hg / gram of activated carbon.

This is supported by other studies that get results that are magnetic Fe_3O_4 of the carbon powder can absorb Fe heavy metal with a weight percentage of 6.08% through EDX testing for the presence of metal after treatment [4].

Therefore, researchers are interested in providing innovative designs and systems of Kuantan River water filtration products through 3 stages, namely purification & coagulation, adsorption, and disinfection. The objectives of this study are:

- Analyze the effectiveness of ACCOALTIC's working principle in the process of purifying raw water of the Kuantan River polluted with Hg waste originating from Unlicensed Gold Mining Activities.
- Presenting the results of the development of ACCOALTIC in the form of bottom loading dispensers.

2. RESEARCH METHODOLOGY

The research was carried out through 6 stages, namely preparation, design, magnetic composite manufacturing Fe_3O_4 activated carbon, test sample collection, sample testing, measurement result data analysis, and manufacture of ACCOALTIC bottom loading dispenser.

Research tools or instruments used are laboratory equipment. While the water used is Kuantan River water, rubber sawdust, distilled water 250 grams, KOH 200 grams, HCl, PVDF 5% 0.758 grams, Fe_3O_4 10% 1,516 grams, and $\text{Al}_2(\text{SO}_4)_3$.

The population of this study is Kuantan River water in Kuantan Singingi Regency, Riau Province, with river water samples in Sawah Village. Sample selection is done by purposive sampling technique. The shooting location is shown in the following image.

Before testing, several samples will be prepared with information, namely:

- Sample 1: Kuantan River water before treatment.
- Sample 2: Kuantan River water after tank treatment 1 – filtration by river stone, brick, gravel, and coagulation by $\text{Al}_2(\text{SO}_4)_3$.
- Sample 3: Kuantan River water after tank 1 and 2 treatment – adsorption by magnetic composite adsorbent Fe_3O_4 of activated carbon.
- Sample 4: Kuantan River water after tank treatment 1, 2, and 3 – disinfection by ultraviolet lamp.
- Sample 5: Kuantan River water after treatment of UPTD Clean Water Provider, especially in Teluk Kuantan Unit.

- Carbon sample: magnetic composite Fe_3O_4 activated carbon after treatment of tanks 1 and 2.

Data were collected by setting in the laboratory using quantitative experimental methods. The data collection tool is shown in the Table 1.

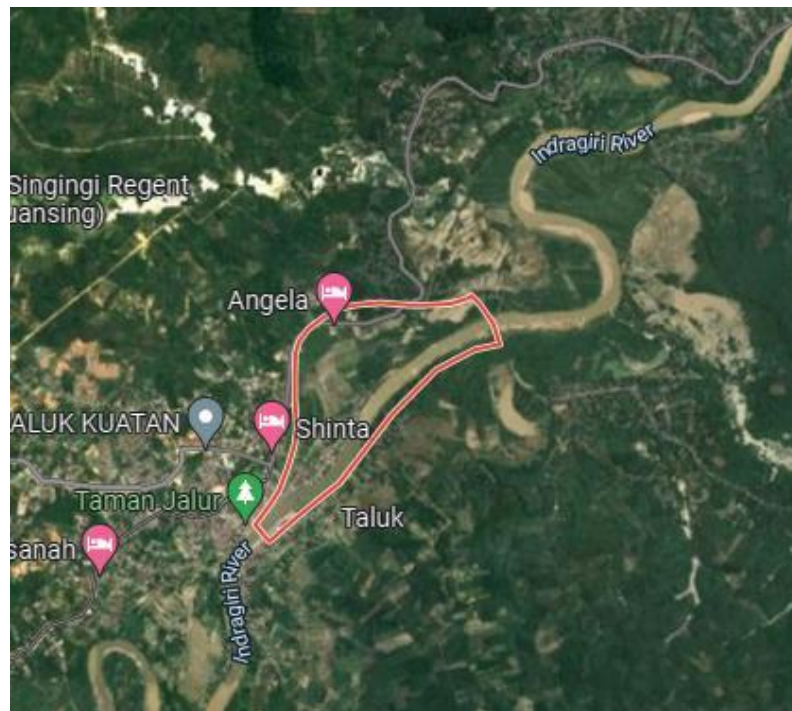


Figure 1. Sampling area [5].

Table 1. Research data collection tools.

Test parameters	Research instruments	Samples used	Measurement scale
Turbidity level	Turbidity meter	1 – 2 – 3 – 4 – 5	NTU
Presence of Hg	X-Ray diffraction (XRD)	Carbon	a.u.
Hg concentration	Atomic absorption spectrophotometry (SSA)	1 and 4	Mg/l
Number of <i>E. coli</i>	Ceramic membrane	1 and 4	CFU/100 ml

That is data analysis by quantitative methods – parametric statistics for turbidity and presence of Hg as well as descriptive statistics for the number of *E. coli* bacteria.

3. RESULTS AND DISCUSSION

3.1. ACCOALTIC Realization

ACCOALTIC is realized in the form of 3 laboratory-scale tanks by utilizing a gravity system. The working principle of ACCOALTIC starts from tank 1 which has a higher position than tanks 2 and 3. Kuantan River water is put in the first tank to go through the purification and coagulation process, then the water will enter the second tank for the adsorption process, then the water will enter the third tank to go through the disinfection process. The previous realization of ACCOALTIC is shown in the following Figure 2.

3.1.1. Turbidity Meter Testing

Turbidity levels were tested for each sample (Kuantan River water) before and after treatment of river stones, bricks, gravel, and $\text{Al}_2(\text{SO}_4)_3$. River stones, bricks, gravel as filtration are intended to filter garbage/large particles originating from raw water sources. The test results can be seen in the following Table 2.



Figure 2. ACCOALTIC realization.

Table 2. Water turbidity test results.

Sample	Testing to-					Average
	1	2	3	4	5	
Maximum levels	25	25	25	25	25	25
Sample 1	72	72	72	72	72	72
Sample 2	0.1	0.1	0.1	0.1	0.1	0.1
Sample 3	0.1	0.1	0.1	0.1	0.1	0.1
Sample 4	0.1	0.1	0.1	0.1	0.1	0.1
Sample 5	1	1	1	1	1	1

In Table 2, the turbidity value of each sample appears. The value of clean water is a clean water standard based on the Ministry of Health [6] and tests conducted by researchers. If averaged, the turbidity value after treatment is 0.1 NTU. This is also evidence from the physical water that looks clearer than before as shown in the following picture.



Figure 3. Samples before (left) and after (right) treatment.

The decrease turbidity value occurs due to the nature of $\text{Al}_2(\text{SO}_4)_3$ (1 gram treatment with 5 minutes in a 1500 ml tube) contains aluminum sulfate which can remove / neutralize the charge on the particles. The faster the stirring process using a magnetic stirrer, the faster the coagulation process occurs.

3.1.2. Pengujian X-Ray Diffraction (XRD)

Activated carbon is defined as carbon that is black in color and has high porosity and has a large adsorption power against harmful substances [7]. The results of XRD testing of carbon samples in this study are as follows, as seen in Figure 4.

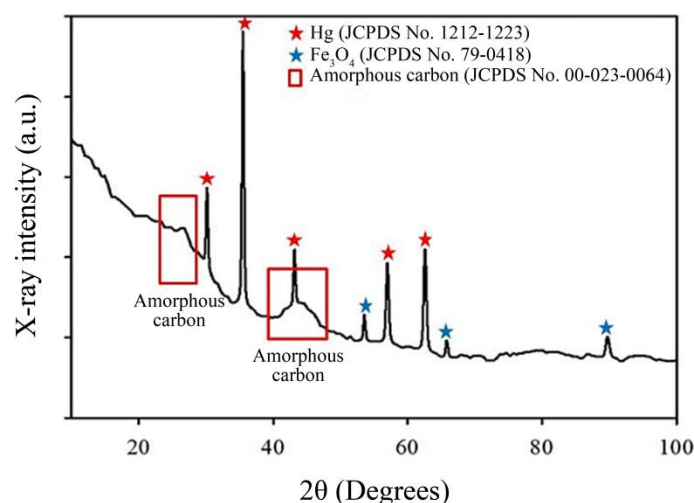


Figure 4. XRD test results of carbon samples.

In Figure 4, it shows the results that in carbon samples there is a heavy metal element, Hg. That is, the adsorption experiment carried out was successful. From the picture above, you can see the peaks of the XRD results on carbon samples. It was found that the peak showed the presence of Hg - red color, and Fe_3O_4 - Blue. There is also shown the presence of amorphous carbon - carbon that has no crystalline structure, in the image marked with red squares in some parts of the graph. Next, SSA testing is done to see the Hg concentrate present in the sample. The comparison before and after the treatment of 3 tanks in is:

$$\%Derivation = \left| \frac{\text{Initial score} - \text{Final score}}{\text{Initial score}} \right| \times 100\% = \left| \frac{0.0316 - 0.0072}{0.0316} \right| \times 100\% = 77.21\% \quad (1)$$

Successful binding of Hg by magnetite compounds (Fe_3O_4) activated carbon is due to the nature of activated carbon itself. In this adsorption process, activated carbon function is as an adsorbent and metal ion such as Hg as adsorbate. Addition of magnetite compounds (Fe_3O_4) Into activated carbon is able to make the material have magnetic properties and overcome the problem of scattered activated carbon collection. The activated carbon is relatively free of deposits, its surface is wide and its pores have been opened. So, it has high absorbency. On the surface of activated carbon, it is positively charged because it releases electrons. Therefore, the surface of this activated carbon is able to adsorb negatively charged anions (electrochemical mechanism).

Relevant research discusses the study of Coconut Shell Activated Charcoal in Water Purification of New Housing Wells in Andai River Area. The result obtained is that activated charcoal is made from coconut shells with the addition of coagulants $\text{Al}_2(\text{SO}_4)_3$ can be applied in adsorbing heavy metals such as Fe, Mn, and Al [8].

3.1.3. Bacterial Filter Membrane Testing

It is based on testing level of *E. coli* bacteria in Kuantan River water in samples 1 and 4 obtained results in the Table 3.

Table 3. Recapitulation of bacterial test results.

Characteristic	Result		Information
	Sample 1	Sample 4	Test methods
<i>E. coli</i>	410	2	SNI 3554:2015 Point 3.28.2

The unit of testing is CFU/100 mL. In the table, we can see the difference in value between water before treatment, which is 410 and after treatment, which is 2. Description of the test letter can be seen on the drive link.

Table 3 showed a very significant decrease in bacteria levels. If the percentage reduction in *E. coli* is calculated, the following results are obtained.

$$\%Derivation = \left| \frac{Initial\ score - Final\ score}{Initial\ score} \right| \times 100\% = \left| \frac{410 - 2}{410} \right| \times 100\% = 99.51\% \quad (2)$$

From this percentage value, it can be said that ACCOALTIC, especially in tank 3, is successful and effective in eliminating most of the *E. coli* bacteria in Kuantan River water. This decrease occurs due to the nature of UV lamps / UV light in reducing the number of *E. coli* bacteria. The beam kills the microorganism (germicide) of the mercury fog lamp emitted exclusively at a wavelength of 2537 Angstrom units (253.7 millimicrons). When UV light passes through the material, energy is freed up to the electron orbitals in the constituent atoms. This absorbed energy causes the energy state of the atoms to rise and change their reactivity.

3.2. ACCOALTIC Development

To maximize and facilitate the function of ACCOALTIC in life, researchers developed a tool into a form of "bottom loading dispenser". This is also commonly referred to as a "bottom gallon dispenser" with 2 faucets. Working on the development of ACCOALTIC took time from May – July 2023. Discussions and tool making were carried out with supervisors and assisted by third parties. The 3D modeling design from the results of ACCOALTIC development can be seen in the Figure 5.



Figure 5. ACCOALTIC 3D modeling design formed bottom loading dispenser.

The characteristic of the type of bottom loading dispenser is that it stands upright (stand dispenser) so it does not need tools as a place. Also, balanced with a body design that is more elegant than the type of top gallon dispenser. The choice of shape is based on the effectiveness of its function in meeting home-scale water needs. The components and specifics of ACCOALTIC are shown in the following Figure 6.

In the Figure 6 can be seen the components of ACCOALTIC bottom loading dispenser form. The components and working principles used are the same as the realization that has been explained in the previous point. At bottom loading dispenser will be pumped up by a special pump. The pump on the dispenser is a wind pump (compressor) that will pump wind into the hermetically sealed gallon cover. The water in gallons will be pushed upwards through the pipes. The cap on the gallon bottle must be tight to avoid leakage that results in water cannot come out of the dispenser.

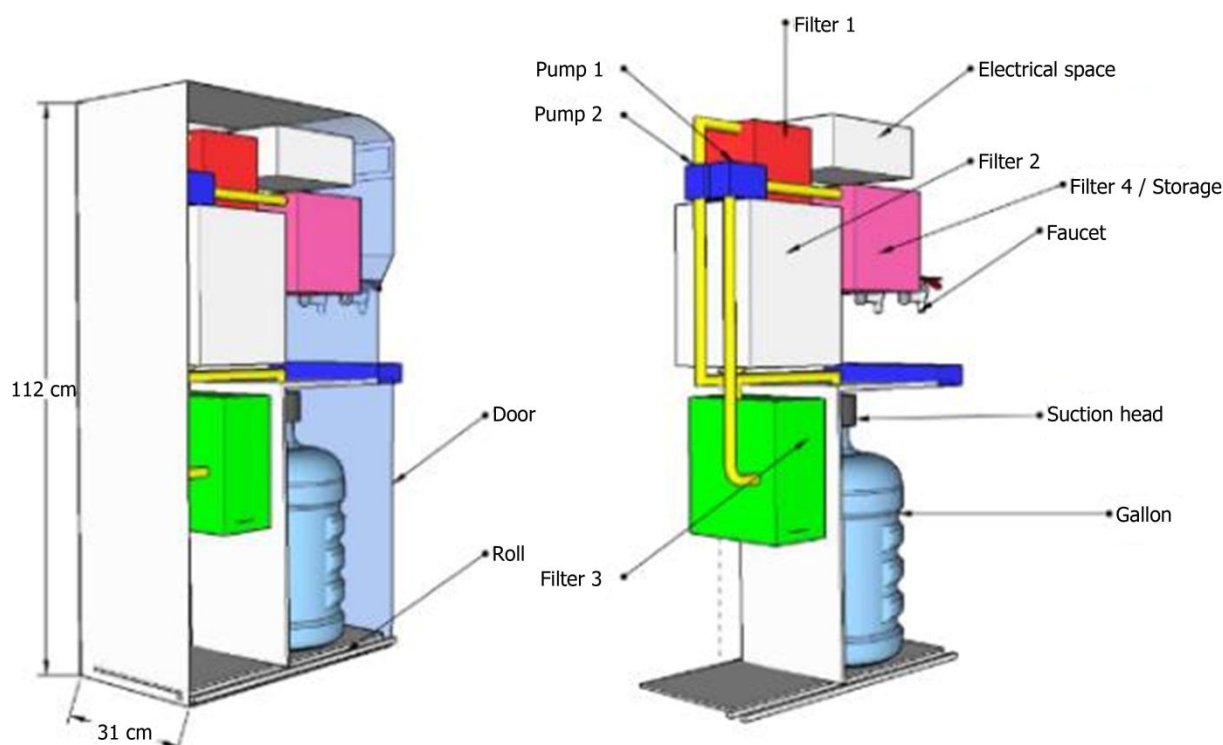


Figure 6. ACCOALTIC components formed by bottom loading dispenser.

Tank 1 which has a higher position than tanks 2 and 3. On ACCOALTIC The shape of the bottom loading dispenser, tank one is at the top left. First, the water from the gallon is raised using a pump to tank 1 which is to go through the purification process by river stones, broken bricks, and gravel and clumps of small particles using $\text{Al}_2(\text{SO}_4)_3$ as a coagulant. The water then goes down to the area of tank two for the adsorption process, which binds the Hg present in the water using a magnetic composite Fe_3O_4 activated carbon. Then, the water is flowed into the third tank using a pump to go through the disinfection process – removing pathogenic microorganisms using an ultraviolet lamp. After all three processes are completed; the water will come out through the faucet.

4. CONCLUSION AND SUGGESTION

The conclusions obtained from this study are:

- The turbidity meter test result of each sample is 0.1 NTU. Meanwhile, from UPTD it is 1 NTU.
- The XRD test results found the presence of heavy metal Hg in the carbon sample after treatment. Meanwhile, the concentration of Hg is decreasing by 77.21%.
- The results of the bacterial filter membrane test resulted on a decrease in the number of bacteria before and after treatment by 99.51 %.
- The development of ACCOALTIC is carried out in the form of bottom loading dispensers for home-scale use.

Suggestion:

- Researchers hope that further development can be carried out on SEM and EDX testing.

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