# Recharge Reservoir Blockage Prevention with Sediment Filter Pond Model

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**ABSTRACT—*Turbid water during the rainy season can reduce seepage even leading to blockage at the base of a recharge reservoir. Sediment filter pond model was designed to reduce level of water turbidity and heavy metal content. This research aimed to determine how effective the use of the sediment filter pond model in reducing level of water turbidity and heavy metal content. More specifically this model was expected to be applicable in a recharge reservoir and could overcome seepage blockage as a main problem currently on it. Therefore, the use of the sediment filter pond model can maintain the high capacity of a recharge reservoir. Laboratory experiments were carried out to examine the research effectiveness. Volume rate and turbidity level of water flow out of the filter pond were measured with 3 variations of water turbidity, sand gradation and natural zeolite weight. This research revealed that the lowest absorbance and actual concentration of heavy metal Lead (Pb) and Cuprum (Cu) at zeolite weight 30 gram comparing with the zeolite weight 25 gram and 20 gram. Percentage of reduction in water turbidity increases with the increase of zeolite weight at each level of water turbidity.***

**Keywords—** recharge reservoir, blockage, sediment filter pond, zeolit

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## 1. INTRODUCTION

In many big cities, groundwater exploitation has been quite intensive. Many industries or hotels have provided quite a lot of wells, till 20 wells for water supply more than 8.000 m3 per day, leading to groundwater drawn down indicated that continuous groundwater drawn-down due to excessive exploitation could cause land subsidence, seawater intrusion and groundwater deterioration [1] [2]. To solve the problems above, natural or artificial recharges have been provided by constructing recharge reservoirs, biopore holes and other recharge techniques. These techniques have not been able to overcome the problems such as flood at rainy season whereas drought at dry season. Therefore, constructing recharge reservoirs in the meantime in Indonesia would be an effective solution. However, during the rainy season river water flowing in the recharge reservoir is turbid and contains sediments and heavy metal that can reduce the amount of water infiltration to aquifer layer and water deterioration in the reservoir. This research aimed to investigate the effect of the use of sediment filter pond model on reducing water turbidity and heavy metal in order to prevent the recharge reservoir from sedimentation and pollution.

Geological Agency predicted that groundwater crises in Jakarta region would occur in the next 15 years if there was no a special effort. Nowadays groundwater consumption is quite high, about 27 million m3/year while groundwater infiltration is only about 17 juta m3/year [3]. Meanwhile, the low quality of surface water in Jakarta promoted people tend to use groundwater. However, excessive uses of groundwater have caused groundwater drawn-down from 50 m to 150 m below ground surface, resulting in lands subsidence and seawater inundation. Groundwater crises in Yogyakarta was caused by many factors including policy maker or local government. There were three factors causing the decrease of groundwater quality and volume in Yogyakarta, including bad landscape management, sanitary management and unrestricted supervision of unlawful environment [4]. Moreover, areas of paddy field or garden also have been changed for areas of housing or shopping and others.

Turbidity level of surface water particularly river water is usually very high during rainy seasons. Environmental degradation especially in relation to decreasing forest areas followed by planting area extension without conservation has significantly contributed to the change of river flow behavior and the increase of turbidity [5]. Turbidity indicates the amount of particles mixing with water. The particles that make water turbid include: Clay; Mud sediment; Fine particles of organic and non-organic materials; Dissolvable organic mixture; Plancton; and Very fine organism.

Water is considered to be turbid when containing quite much suspension particle that leads to be muddy and dirty [6]. Floating particles such as colloid usually makes water turbid. The turbid water is also caused by organic particles, very fine organism, mud and clay that are not immediately deposited. Industrial waste can increase organic and non-organic particles that lead to water turbidity [7].

Scientists often measure water turbidity with total suspension density in a water sample. The turbidity measurement with turbidiuster measures the amount of light to pass through a water sample. The suspension particles will disperse incoming light that leads to reduce transmitted light intensity. Water turbidity causes light dispersion and limits lighting into water. Light transmission into water is influenced by not only the amount of dissolved or floating particles but also their shapes and sizes in the water. Water turbidity level is converted into SiO2 size with mg/l unit. The more turbid the water the higher the electrical conductivity and the more the density [8]


**Figure 1.** Turbidity of river water

Water turbidity in a flood river is greatly caused by coarse suspension materials from ground surface due to erosion during the rainy season. The suspension materials include clay, mud, well-distributed organic materials and other suspension fine particles. High water turbidity can cause disturbance of osmoregulation system such as respiration and visibility of aquatic organism, and reduce light penetration into water depth. Turbidity level can also make filtration effort difficult and reduce disinfection effectiveness at water purification [9].

**Tabel 1.** Water turbidity levels

| ***No.*** | ***Turbidity levels*** | ***TSM (NTUl)*** |
|---|---|---|
| 1 | Medium | 15 – 25 |
| 2 | Slightly turbid | 25 – 35 |
| 3 | Turbid | 35 – 50 |
| 4 | Very turbid | 50 |

Water turbidity should be considered in water supply for public community because it will make esthetic degradation, filtration effort difficult and reduce disinfection effectiveness For easily deposited particles, turbidity can be eliminated by sedimentation and filtration while filtration and coagulation with coagulant followed by filtration and sedimentation is a suitable method to eliminate turbidity of water containing very fine particles. [10]

Zeolite mineral is chemical compound of alumina silicate hydrate with alkali metal as a mineral group containing several types of mineral. zeolite term is originated from Greece, meaning boiling stones, its water is released when being heated. Natural zeolite is physically and chemically hydrated silica alumina compound which can be used as absorbent, cathion exchanger and catalyst [11][12].

Natural zeolite consists of hydrate silicate alumino compound and alkali metal. The zeolite has physical and chemical behavior such as high hydration degree, low space density, low cathion exchangeability, uniform molecule channel in hydrated crystal, capability as catalyst and conductivity for electrical flow [13].

When using zeolite as an industrial mining material, it is strongly controlled by its physical and chemical properties. These properties greatly influence industrial process including: 1) Absorbent, Absorbent is bonding process for a molecule or chemical element on other chemical element surfaces. The use of zeolite as an absorbing material; 2) Cathion exchanger, Natural mineral such as zeolite and clay (chemical compound of cathions in zeolite) can be exchanged with other cathions outside zeolite frame/chain in a chemical solution. This mechanism is supported by ions in zeolite crystal pores that always maintain the neutral of electrical charges and also by freely movable ions, cathion exchange capacity with respect to size, ion charge and zeolite types; 3) Catalyst, Catalyst reaction occurs in zeolite crystal pores. Therefore, necessary properties of zeolite as catalyst are its pore size, big uncharged volume in addition to ratio of Si and Al atoms that influence the properties of zeolite as catalyst. These properties are affected by electrical charge behavior and structures owned in the hollow space and surface of zeolite. Zeolite will behave in respect to its chemical structure after treatment process.

In conjunction with zeolite properties, it can be used to eliminate odor and color or to control pollution. As cathion exchanger, zeolite can also be used to overcome pollution resulting from industrial waste water because it can reduce ammonium concentration in the water. The capacity of zeolite to absorb gas CO2 and to increase oxygen concentration particularly mordenite type that enables it to overcome air pollution. By chemically activating NaOH and H2SO4 [14].

Zeolite was used for river water treatment to obtain hygienic water. In addition, Zeolite can also be used to exchange/catch metals such as iron and manganese available in the water. The availability of great amount of iron and manganese in the water causes loss in its use for housing and industrial purposes.

The sediment filter pond was used as media for filtering turbid river water containing sediments to reduce its turbidity level when flowing into recharge reservoirs. Therefore, water infiltration to aquifer layer does not contain soil particles that can lead to the reservoir bed blockage.

This filter model includes sand and gravel layer as a part of drainage system, which is the overall flow into open filtering column for washing off with flushing pipe. This process starts from flowing turbid water into sedimentation pond to deposit particles from river flow and to separate solid particles from supernatant. The supernatant at surface layer can be used as influent to filter using palm fiber as filtering media. After filtering in the filter pond, water flow in and out of the recharge reservoir has reduced its heavy metal content and turbidity.

## 2. RESEARCH METHODS

Turbid water was pumped into sedimentation pond, then flowing to the initial filter pond. When there is abundant sediment in the sedimentation pond, it is then flushed through flushing channel/pipe. As a result, less-turbid water flows into the final filter pond containing sand and zeolite layers. The water flowing out of this pond was tested its turbidity and its absorption using Atomic Absorption Spectroscope (AAS). In this research, water turbidity was varied in 3 levels: rather turbid, turbid and very turbid. Zeolite was also varied in 3 weights: 20gr, 25gr and 30gr.

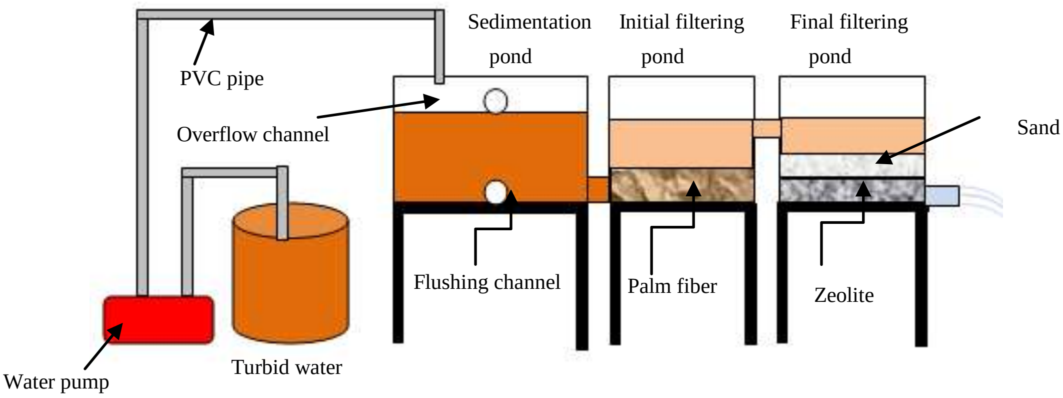



**Figure 2.** Sediment filter pond model

## 3. RESEARCH RESULT

### 3.1 *Results of heavy metal testing*

The size of ion for absorbed Lead Metal (Pb) and Cuprum (Cu) is calculated using the following equations:

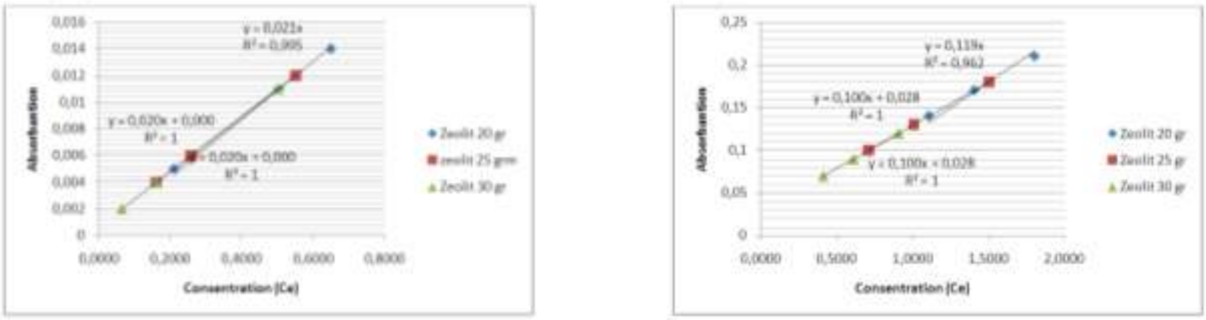
$$qe = \frac{(C0-Ce)}{W}.V \qquad (1)$$

Using the regression equation: y = 0,025x + 0,0007 the following equation was obtained:

$$Ce = \frac{(Absorbansi\ -0,0007)}{0,025} \qquad (2)$$

**Table 2.** Water test analyses using SSA for Lead Metal (Pb) and Cuprum (Cu)

| *Water turbidity* | *pH* | *Absorbance* | | *Co (ppm)* | *Ce (ppm)* | | *Co-Ce* | | *qe (mg/gr)* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *Pb* | *Cu* | | *Pb* | *Cu* | *Pb* | *Cu* | *Pb* | *Cu* |
| Zeolite 20 gr | | | | | | | | | | |
| Rather turbid | 6 | 0,005 | 0,14 | 5 | 0,2098 | 1,1067 | 4,7902 | 3,8933 | 0,0240 | 0,0195 |
| Turbid | 6 | 0,011 | 0,17 | 5 | 0,5024 | 1,4045 | 4,4976 | 3,5955 | 0,0225 | 0,0180 |
| Very turbid | 6 | 0,014 | 0,21 | 5 | 0,6488 | 1,8015 | 4,3512 | 3,1985 | 0,0218 | 0,0160 |
| Zeolite 25 gr | | | | | | | | | | |
| Rather turbid | 6 | 0,004 | 0,10 | 5 | 0,1610 | 0,7097 | 4,8390 | 4,2903 | 0,0242 | 0,0215 |
| Turbid | 6 | 0,006 | 0,13 | 5 | 0,2585 | 1,0074 | 4,7415 | 3,9926 | 0,0237 | 0,0200 |
| Very turbid | 6 | 0,012 | 0,18 | 5 | 0,5512 | 1,5037 | 4,4488 | 3,4963 | 0,0222 | 0,0175 |
| Zeolite 30 gr | | | | | | | | | | |
| Rather turbid | 6 | 0,002 | 0,07 | 5 | 0,0634 | 0,4119 | 4,9366 | 4,5881 | 0,0247 | 0,0229 |
| Turbid | 6 | 0,004 | 0,09 | 5 | 0,1610 | 0,6104 | 4,8390 | 4,3896 | 0,0242 | 0,0219 |
| Very turbid | 6 | 0,011 | 0,12 | 5 | 0,5024 | 0,9082 | 4,4976 | 4,0918 | 0,0225 | 0,0205 |




(a) (b)

**Figure 3:** Correlation between concentration and absorbance (a) Lead Metal (b) Cuprum

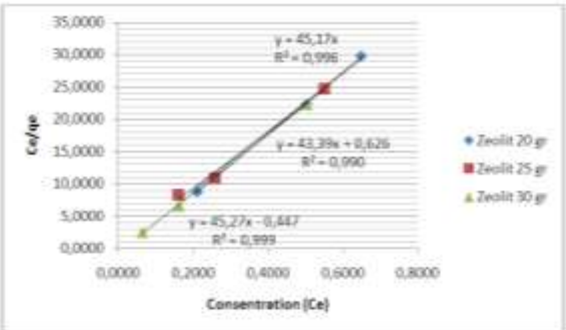
As shown in Table 2 and Figure 3, the heavier the zeolite weight the lower the absorbance of heavy metal Lead and Cuprum. Figure 1 shows strong correlation between concentration and absorbance, even for zeolite weight 25 gr and 30 gr it shows very strong correlation, R2=1.

**Tabel 3.** Langmuir dan Freundlich model testing analyses

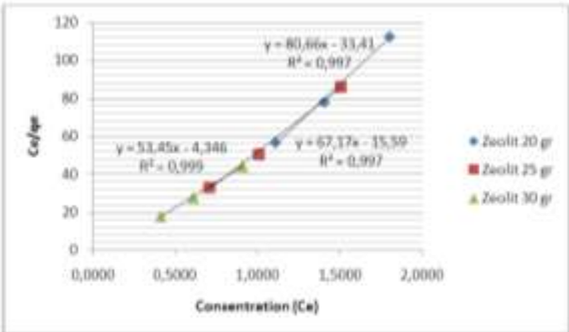
| ***Water turbidity*** | ***Absorbance*** | | ***Concentra-tion (Ce)*** | | ***Qe*** | | ***log Ce*** | | ***log qe*** | | ***Ce/qe*** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ***Pb*** | ***Cu*** | ***Pb*** | ***Cu*** | ***Pb*** | ***Cu*** | ***Pb*** | ***Cu*** | ***Pb*** | ***Cu*** | ***Pb*** | ***Cu*** |
| Zeolite 20 gr | | | | | | | | | | | | |
| Rather turbid | 0,005 | 0,14 | 0,2098 | 1,1067 | 0,0240 | 0,0195 | -0,6781 | 0,0440 | -1,6197 | -1,709 | 8,7576 | 10,7752 |
| Turbid | 0,011 | 0,17 | 0,5024 | 1,4045 | 0,0225 | 0,0180 | -0,2989 | 0,1470 | -1,6478 | -1,744 | 22,3427 | 27,9480 |
| Very turbid | 0,014 | 0,21 | 0,6488 | 1,8015 | 0,0218 | 0,0160 | -0,1878 | 0,2550 | -1,6615 | -1,795 | 29,8206 | 40,5677 |
| Zeolite 25 gr | | | | | | | | | | | | |
| Rather turbid | 0,004 | 0,1 | 0,1610 | 0,7097 | 0,0242 | 0,0215 | -0,7931 | -0,1480 | -1,6161 | -1,667 | 6,6532 | 7,5041 |
| Turbid | 0,006 | 0,13 | 0,2585 | 1,0074 | 0,0237 | 0,0200 | -0,5875 | 0,0032 | -1,6252 | 1,698 | 10,9053 | 12,9509 |
| Very turbid | 0,012 | 0,18 | 0,5512 | 1,5037 | 0,0222 | 0,0175 | -0,2586 | 0,1770 | -1,6536 | -1,706 | 24,7807 | 31,5318 |
| Zeolite 30 gr | | | | | | | | | | | | |
| Rather turbid | 0,002 | 0,07 | 0,0634 | 0,4119 | 0,0247 | 0,0229 | -1,1979 | -0,3850 | -1,6073 | -1,889 | 2,5692 | 2,7643 |
| Turbid | 0,004 | 0,09 | 0,1610 | 0,604 | 0,0242 | 0,0219 | -0,7932 | -0,2140 | -1,6162 | -1,659 | 6,6532 | 7,3344 |
| Very turbid | 0,011 | 0,12 | 0,5024 | 0,9082 | 0,0225 | 0,0205 | -0,2990 | -0,0410 | -1,6478 | -1,688 | 22,3427 | 24,5583 |

## Langmuir model

Absorption equilibrium model was carried out to determine the effectiveness of process between ion of metal Pb dan Cu with zeolite based on correlation linearity Ce/qe vs Ce.




(a)




(b)

**Figure 4.** Langmuir model testing analyses (a) Lead Metal (b) Cuprum

From Figur 4 shows the strong correlation Ce/qe vs Ce at zeolite weight 30 gr, which indicated by R2 = 0,999 or approaching 1.

## Freundlich Model

Isothermal model or Freundlich equilibrium, was also investigated in respect to correlation linearity log qe vs log Ce as shown in Figure 5.

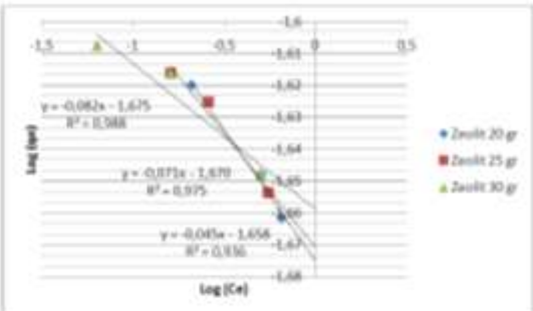



**Figure 5.** Freundlich model testing analyses

Strong correlation Ce/qe vs Ce was shown for zeolite weight 30 gr, indicated by $R2 = 0,988$ or approaching 1.

**Tabel 4.** Correlation between zeolite weight and water turbidity reduction

| *Zeolite weight (gr)* | *Water turbidity reduction (%)* | | |
|---|---|---|---|
| | *Rather turbid* | *Turbid* | *Very turbid* |
| 20 | 60,00 | 57,14 | 54,72 |
| 25 | 66,67 | 64,29 | 62,26 |
| 30 | 76,67 | 71,43 | 67,92 |

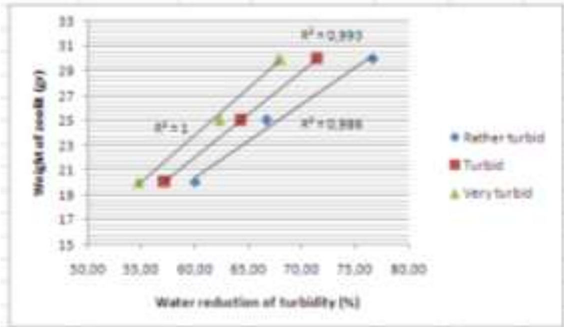



**Figure 5.** Correlation between zeolite weight and water turbidity reduction

As shown in Tabel 4 and Figure 5, percentage of water turbidity reduces with the increase of zeolite weight for each level of water turbidity. For zeolite weight 30 gr, water turbidity reduces 76,67%, which is higher than those for zeolite weight 25 gr with 66,67% and 20 gr with 60%. These phenomena indicated that the heavier the zeolite weight the lower the water turbidity and the absorbance of heavy metal.

## 4. CONCLUSIONS

The lowest value of absorbance measured for turbid water using SSA equipment was obtained for zeolite weight 30 gr with 0.002 and 0.007 respectively for Pb and Cu. Percentage of reduction in water turbidity increases with the increase of zeolite weight at each level of water turbidity.

## 5. ACKNOWLEDGEMENTS

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