- ACTIVATED DRY SAND FILTER -

AS AN ALTERNATIVE TO REDUCE THE CONCENTRATION OF Fe AND Mn IN WATER TREATMENT

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ABSTRACT

The availability of water which are use for various purposes such as for primary purpose, as well as for other every day activities can not be ignored from the human lives. People has been trying to find water resources in numerous ways, within groups or individually.

In a large community, The Water Supply Company/Drinking Water Management Service have the responsibility to provide drinking water that can be used savely. However, up until now the capability of The Water Supply Interprise in Indonesia to provide save drinking water are still limited. Thus there are still a large number of people that have not yet receive clean, high quality water. The sources of water that are being used by the people not being served by The Water Supply Company varies according to their environmental condition, such as surface water, shallow groundwater, deep groundwater or even the spring water.

In the urban area the usual source of water are groundwater that comes from deep or shallow wells. The problems with the quality of water from wells that always comes up are the high contents of Iron and Manganese. That is because of the goelogical condition of Indonesia with its many volcanic mountains, so that latosol soil high in Iron and Manganese are commonly found. This kind of soil are the caused of high content of Iron and Manganese in groundwater.

To help solve this problem, a study was carried out on the possibility of using Activated Dry Sand Filter as an alternative treatment for Iron and Manganese. The results would give us the information on the right methode to reduce the concentration of Iron and Manganese in water efectively and eficiently, so it could be generally applied.

INTRODUCTION

To be used savely water have to meet certain criteria concerning their quality and quantity. By quality it means that it has to undergo a certain treatment technique appropriately. In choosing the right water treatment technique, the primary factor to look at is the quality of the raw water. Aside from that, other factors to consider is the simplicity of the system, its economic point of view and the easyness of its operation and maintenance.

A great number of Indonesian population have not yet had the opportunity to receive drinking water facilities which are representative, because the capacity of *"The Water Supply Company"* to serve all the need is still limited. Thus to provide for the need of drinking water people had been trying to find water resouces individually, while their quality are still questionable.

Water resources that generally used are ground water from dug well or drilled well. The problem of this shallow ground water is the high content of iron and manganese. Most of the ground water sample which are analized in TL- ITB Laboratory (Laboratory of Environmental Engineering-ITB) contained Iron and Manganese higher in concentration that is allowed for drinking water. Thus an alternative treatment for Iron and Manganese that can be applied efectively and eficiently had to be constructed.

OBJECTIVE OF THE STUDY

The aim of this work paper is to develop a process and to design an instrument that is usable and applicable in reducing the concentration of Iron and Manganese on water resources that are used for domestic purposes.

The objective is to create a healthier community by accustoming them to use clean and save water, and also help the community, especially in the slum area to solve the problem of providing drinking water with an eficient and economical water management.

The study and research had been done in two locations, i.e :

1. Research in the Laboratorium.
2. Field study , which was done in Sekelimus Village, sub-district Batununggal, Bandung.

BACKGROUND OF THE STUDY

The quality of groundwater depends on the composition of the soil lining which are passed by that water. Soil lining in Indonesia usually are products of volcanic stones sedimentation which contain high concentration of iron and manganese, for example the latosol soil. Iron and Manganese dissolve easily in water, that is why generally the groundwater in Indonesia contain high enough concentration of Iron and Manganese.

Naturally Iron and Manganese can be found in the form of *Ferrous Bicarbonate, Ferrous Hidroxide, Ferrous Sulfate, Organic Iron, Mangan Bicarbonate* and *Mangan Sulfate.*

Fe and Mn in water could produce color, *Ferrous Oxide* could produce red color in water and Manganese Oxide could change the color of water to brownish black. The presence of iron and manganese in water could caused health hazzard, produce spots on clothes and other appliances. Beside that Fe and Mn could also support the growth of microorganisms which could reduce the pipe's efectivity.

In water, iron present in a soluble form, colorless and its solubility would increase with the increase of soluble Carbon Dioxide (CO_2). Water containing Ferrous Bicarbonate when contacted with Oxygen would form white precipitate, which turned yellowish and then turned again to brownish red precipitate of Ferrous Oxyde [7].

THE PROCESS OF SEPARATING IRON FROM WATER

The process of reducting the concentration of iron from water could be done in various way, i.e. [3,4,6,7]:

- Aeration, Precipitation, Filtration.
- Na-Cation Exchanger, Water Softening Process.
- Hydrogen-Cation Exchanger.
- Lime Soda Water Softening.
- Two Stage Lime and Soda Na-Exchanger.
- Converting Manganese --------> Zeolith.

The simplest ones are aeration, precipitation and filtration. The principles of those treatments are converting the oxidation number of iron from Fe^{2+} to Fe^{3+}, where iron in the form of Fe^{3+} could be precipitated and then filtered. The process could be described by this chemical reaction :

$$2\,Fe(HCO_3)_2 + 1/2\,O_2 + H_2O \longrightarrow 2Fe(OH)_3 + 4\,CO_2$$

The oxidation process depend on two things, i.e. :

- pH, where the higher the pH, the faster the reaction and vice versa.
- Contact time, the longer the contact time the greater the separation.

TABLE 1
THE EFFECT OF pH AND CONTACT TIME
ON THE REDUCTION OF IRON CONCENTRATION

Raw Water		After Aeration and Filtration		
pH	Iron Content (ppm)	15 min	30 min	60 min
5,00	10	9,0	-	7,5
6,15	10	4,4	3,5	2,5
6,80	10	0,2	0,1	0,1
8,05	10	< 0,1	< 0,1	< 0,1

Source : Laboratory of Environmental Engineering, ITB

THE PROCESS OF SEPARATING MANGANESE FROM WATER

The presence of manganese ions in ground water greatly coincide with the kind and condition of the soil lining and soil surface of the area. In nature we could find manganese in compounding form such as : MnO, MnCo and MnSiO.

Methodes that can be applied to separate manganese from water are as follow [3,4,6,7]:.

- Aeration, Precipitation, Filtration.
- Na-Cation Exchanger.
- Hydrogen Cation-Exchanger Process.
- Lime Soda Water Softening Process.
- Manganese Zeolite.

As it was with the iron separation, the simplest methodes to separate manganese from water is by aeration, precipitation and filtration methodes. The oxidation reaction of those process is as follows[3,7]:

$$Mn(HCO_3)_2 + 1/2\ O_2 + H_2O \longrightarrow Mn(OH)_3 + 4\ CO_2$$

TABLE 2
EFFECT OF pH AND CONTACT TIME
ON THE REDUCTION OF MANGANESE

Raw Water		After Aeration and Filtration		
pH	Manganese (ppm)	15 min	30 min	60 min
8,5	10	-	-	10,0
9,3	10	8,5	8,0	7,5
9,7	10	3,0	1,3	1,0
10,3	10	< 0,02	< 0,02	< 0,02

Source : Laboratory of Environmental Engineering-ITB

AERATION PROCESS

The aeration process that describe here is the entering of air which contain oxygen into the water. The oxygen which entered into the water would then be used to oxydate the solute Fe and Mn to the precipitate form. Aeration is a process of gas transfer.[5] This process are influenced by several factors :

- The original condition of the gas, which is generally expressed in the form of spesific gas coefficient or coeffisient distribution of k_D . $k_D = C_a / C_g$

  Where : C_a = Saturated concentration of gas in the gas phase (g/m^3)

  C_g = Concentration of gas in gas phase (g/m^3)

- The saturated concentration of gas in the gas phase, which is related to the partial pressure of the gas in the gas phase. That condition is expressed in the Henry's Law ; $C_a = k_h . p$

  Where : k_h = The constant number of Henry

  p = The partial pressure of the gas
- The temperature of water.
- The impuritical condition of the water.
- The concentration of the related gas.

In this aeration process, the most important factor is the difusion fenomena. Difusion is a tendency of a substance, in this case is air filled with oxygen, to extend itself all over an empty space. The difusion of gas in the gas phase is alot faster than difusion of gas in the liquid phase (about 10^4 times faster). Based on this property a concept of gas transfer coefficient was developed. During the process of. gas transfer from the gas phase into the water, the distribution of gas concentration can be reflected by *Figure 1.*

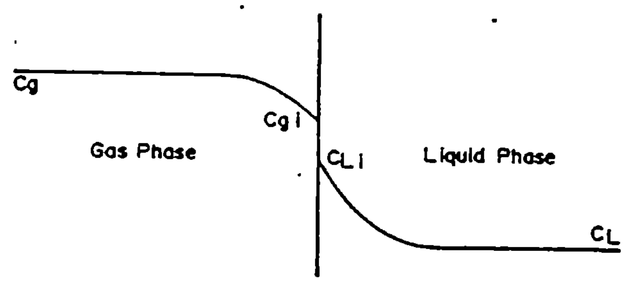

Figure 1 . Gas Transfer

The concentration reduction in the gas phase occured in the direction of surface border between the gas phase and the liquid phase of C_g (concentration of gas in the gas phase) to Cgi (concentration of gas phase on the inter phase surface). On the liquid part of the inter-phase surface the gas concentration of the liquid phase would then again be reduced to C_{Li} because of the gas absorption process into the liquid phase. The concentration would go on reducing until it reach a stabil point of C_L. Thus based on the Fick's Law we could say that :

- For the gas phase : $m = k_g . A . (C_g - C_{gi})$
- For the liquid phase : $m = k_L . A . (C_{Li} - C_L)$

Where : m = mass that being transported per time unit (g/sec)

k_g = partial gas transfer coefficient for the gas phase (m/sec)

k_L = partial gas transfer coefficient for the liquid phase (m/sec)

A = the width of the inter phase surface

Combiningly, the total gas transfer coefficient K_L :

$$\frac{1}{K_L} = \frac{1}{k_L} + \frac{k_D}{k_g} \qquad \text{(sec/m)}$$

. The total mass transport :

$$n = A \cdot K_L \cdot (k_D \cdot C_g - C_L) \qquad \text{(g/sec)}$$

FILTRATION

Filtration is a refining process. The media that could be used as filters is the granular media such as *silica sand, anthracite grains, magnetite grains,* and *granite sand.*

Because of its granular property, the structure of the sand filter consist of porous between each particle which enables water to pass through, but would prevent other materials of larger sizes than each porous of passing through. The soluble Fe and Mn after being oxidized would become precipitate that will be filtered on the sand filter.

The properties which influenced the capacity of the filter media on the filtration process are the size and shape of each particle and also the particle size distribution. On the sand filter the term efective size (E) is recognized as the size of particle on the 10 percentage of the smallest size distribution, and the coefficient of nonuniformity (U) which is the ratio of the particle's size on the 60 percentage distribution and the particle's size on the 10 percentage distribution.

$$E = P_{10} \quad \text{and} \quad U = P_{60} / P_{10}$$

The sand that is used as the filter media could be activated with the use of $KMnO_4$ solutions. The $KMnO_4$ activated sand would then posses MnO_2 lining which could function as autocatalysator and help in the oxidation process of soluble Fe and Mn in water.

ACTIVATED DRY SAND FILTER

Activated dry sand filter is a filter which utilized granular media and is operated in a certain way so that the filter is not submerged in the water being filtered. In that condition the activated dry sand filter is a system which combined the aeration and filtration process on a sand filter media. The basic principle of how the activated dry sand filter works are as follows (Figure 2) :

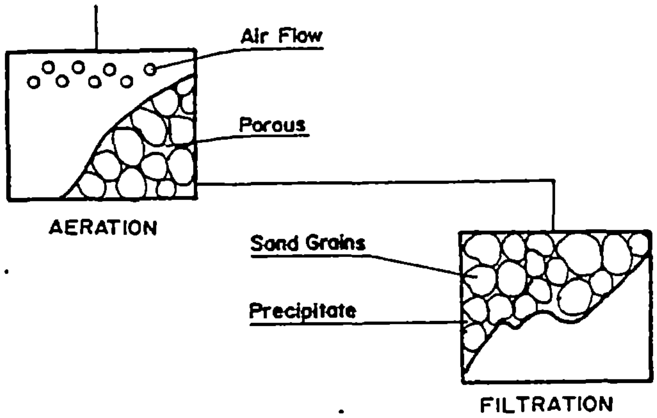

Figure 2 . Activated Dry Sand Filter Process

Water that chanelled through the filter is somehow regulated so that its capacity is smaller than the inter particle's hollow could contained. Thus the hollows is always filled with air and the aeration process could take place and produce Fe and Mn precipitation which then could be filtered by the activated sand filter.

In accordance with the main objective of this study, therefore an alternatif treatment of Fe and Mn which is simple enough to be done by most people, especially those in the slum area need to be created. One such alternatif treatment that can be considered worth developing is the activated dry sand filter. Basicly this activated dry sand filter utilized the simplest Fe and Mn treatment methodes which are aeration and filtration. The particular thing about this system is the simplification of one unit processing, which is without the sedimentation process.

The treatment applied in this system is emphasized on improving the chemical quality especially the concentration of Fe and Mn content.

Apart from that, in view of the instrument which is utilized for this treatment, a modification of a model which is relatively simple and cheap need to be developed with the consideration of its applicability in the field and the use of available materials.

THE LABORATORY RESEARCH

The laboratory research was carried out to determine the characteristic of the model used for the treatment. The works that had been done in the research involved adjusting the variations of parameters which influence the performance of the apparatus in treating raw water, i.e. by adjusting the variations of the water flow (capacity) and the contacting time. The raw water being used is artificial raw water containing Fe and Mn.

Furthermore, in this research the Fe and Mn reduction efficiency were also inspected by examining the Fe and Mn concentration of the water after being through the treatment apparatus. Samples of the treated water was picked out from several efluent points to determine the most efficient contact time.

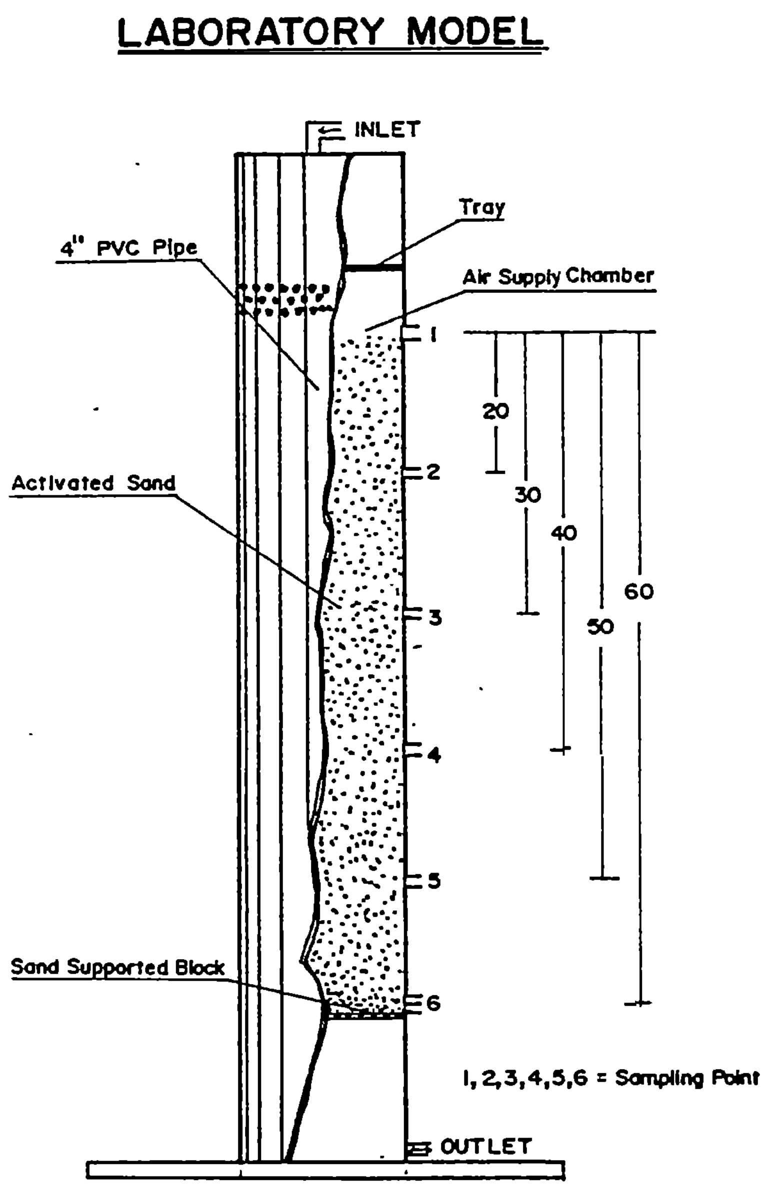

Figure 3. Laboratory Model

Other parameters being varied is the concentration of Fe and Mn that come into the system and the treatment's flow. The variation adjustment of the water flow and concentration was planned as follows :

	C_1	C_2	C_3
Q_1	*	*	*
Q_2	*	*	*
Q_3	*	*	*

Note : - i = 1,2,3,....

- C_i = The concentration of Fe and Mn on i condition

Q_i = Flow/capacity on i condition

In this experiment sampling was done after the water had been flowing for 10 minutes to condition the flow, after that water was sampled and tested on several parameters such as pH, the Fe and Mn contents and its color.

In this laboratory research, the parameters which is examined are :

1. Physical : - Color (Using the colorimetri methode).
   - Temperature (Using a thermometer).
2. Chemical : - pH (Using pH Comparator).
   - Disolved Oxygen (Using DO-meter).
   - Iron (Fe), Using the colorimetri methode
   - Manganese (Mn), Using the colorimetri methode

For this research study, artificial raw water was used to simplify the conditioning process and the treatment being done can be considered exact without the influence of other process.

FIELD RESEARCH

Experimental data obtained from the laboratory study was then tested to be applied in the field. Field study was attempted to obtain informations on the effect of the quantity of water being treated toward the capability of the model, also the application of the model in the real condition. Another thing is to determine the *"security coefficient"*.

Data analysis had been done after the laboratory research and the field study was finished, to determine the characteristic of the treatment system which involves the model itself and the raw water being used. If it is necessary in this phase a modification of the model could be done to obtain the optimum condition.

In this field research a model of 8 inches high with the width of 320 cm^2 was used. Those figure was estimated based on :

- The determination of flow capacity.
  The flow capacity generally yield by hand pump in the research area was about 0,1 l/sec or 360 l/hr.

- The determination of the raw water concentration.
  The raw water from the research location area had an Iron concentration of about 1.8 mg/l and Manganese concentration of about 1.2 mg/l. The standard quality of drinking water from *the Health Departement of Indonesia* for the allowed

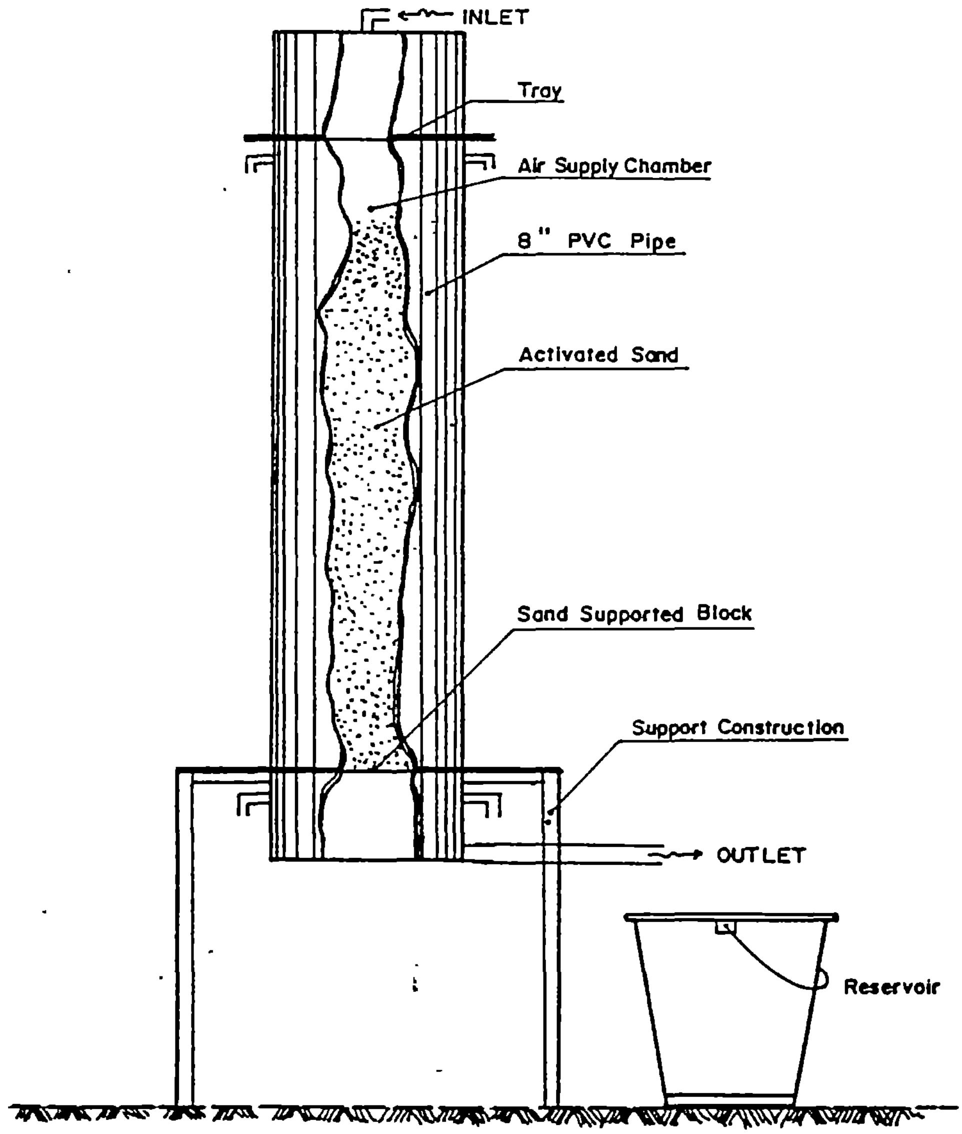

Figure 4. SCALE-UP MODEL IN THE FIELD

maximum concentration of Iron is 1 mg/l and for Manganese is 0,5 mg/l. To improve the quality of the raw water to be of drinking water quality a treatment is needed with the treatment efficiency of :

- Iron = (1,8 - 1)/1.8 x 100 % = 44%
- Manganese = (1,2 - 0,5)/1,2 x 100 % = 83 %

The step to determine the dimension of the apparatus is :

* Formating The Theoretical Dimension.

1. Determine the concentration of raw water
2. Determine the reduction efficiency of Fe and Mn needed
3. Estimate the desired thickness
4. By looking at the model characteristic graph the capacity (Q) can be determine from the area of 81 cm^2 .
5. Determine the treatment capacity.
6. The area of the surface needed can then also be calculated.

* Formating The Real Dimension

The real dimension can be determine from the greatest result of the theoretical dimension for the reduction of Iron and Manganese, and multiply them by the "security" coefficient.

* Example (For Field Study) :

A. Theoretical Diameter

- *Iron*

1. The concentration of raw water = 1,8 mg/l
2. Efficiency = 44 %
3. The estimated thickness = 80 cm
4. We get Q = larger than 60 l/hr, Assumed = 150 l/hr
5. The treatment capacity = 360 l/hr
6. The surface A = 360/150 X the research surface A

   = 2,4 x A

- *Manganese*

1. The concentration raw water = 1,2 mg/l
2. Efficiency = 83 %
3. The estimated thickness = 80 cm
4. We got Q = alot larger than 49 l/hr ;

   Assumed = 120 l/hr
5. The treatment capacity = 360 l/hr
6. The surface A = 360/120 x surface research of A

   = 3 x A

B. The Real Diameter

The largest area is for Manganese which is 3 times the surface (A). The *"security coefficient"* have not been looked at, if we took 1,25 as the *"security coefficient"* therefore the surface area needed is 1,25 x 81 cm^2 or 101,25 cm^2 or with the diameter of 4,5 inch.

From the results of laboratory research and the calculation above the diameter used for that condition is 8 inches with the sand thickness of 80 cm.

One of the objective of this field research is to determine the operating time (the distance between each washing or the total amount of water that can be treated), where the operating time of this model is long enough which is about 3 months.

The amount of water that can be treated can be calculated as follows (Figure comes from datas) :

- The number of user = 30 people
- The amount of water needed = 60 l/person/day
- The amount of water being treated :

  30 people x 60 l/person/day = 1800 l/day

THE RESULTS OF THE STUDY

The field study results that can be collected up until now are as follow :

TABLE 3
EFFICIENCY OF THE MODEL IN THE FIELD

Day	IRON INFLUENT $C_{inf.}$	IRON EFFLUENT $C_{eff.}$	EFFICIENCY (%)	MANGANESE INFLUENT $C_{inf.}$	MANGANESE EFFLUENT $C_{eff.}$	(%)
0	1.80	0.00	100	1.20	0.00	100
1	1.70	0.00	100	1.00	0.00	100
2	1.60	0.00	100	1.00	0.00	100
3	1.60	0.00	100	1.00	0.00	100
7	1.60	0.00	100	1.00	0.00	100
10	1.70	0.00	100	1.00	0.00	100
14	1.60	0.00	100	1.00	0.00	100

Source : Results of The Research

The result of this research is the inovation of a model instalation to reduce the concentration of iron and manganese, with the specification as follows :

- Dry sand filter

  Dry sand filter is meant to create a certain condition so that in the sand there is enough air needed for the aeration process, and that the water flow rapidly or is in the turbulence condition because it went through the granular media and had the chance to contact with air therefore the occuring of the aeration process is highly possible. This aeration process is needed for the oxidation of Iron and Manganese.

- Activated sand filter

  This activated sand filter is used so that a catalysator is achieved for the oxidation process of iron and manganese on the granular media, so it could accelerate the reaction.

Combiningly this apparatus can improved the efficiency of Iron and Manganese reduction and can be considered a model which is economical in money, time and place, beside its simplicity in construction, operation and maintenance.

The term economical is very general and complex, it depend greatly on time, place and situation. To explain this situation, the term economical from the mathematical point of view could be exposed, which is done with the *"Benefit Cost Ratio"* method.

Benefit Cost Ratio (BCR) is the ratio of the total profit and the cost that is needed. Generally the calculation is based on the life term of the instrument.

For the model that is applied to the public there are several things that could be pointed out :

* Economical Lifetime

The model consisted of PVC, activated sand and other supported materials, which in this case is made of iron. The economical life of the model can be expected about 2 years and the sand would have to be replaced once every 2 years, so the economical life time of the sand is 2 years.

* Benefit

The benefit is the amount of water yielded. The quantity of water yield by the instrument during the economical life time of 2 years could be calculated using the data below :

- The number of user : 30 people
- The amount of water needed : 60 l/person/day

So the total amount of water : 2 years x 365 days x 30 people x 60 l/person/day = 1,314,000 liter

* Cost

The cost is the total money put in during the economical life time. The cost amounted to :

A. Investation

- 2 meter PVC 8 in. of 4 mm thick	Rp 30,000
- 11 elbow PVC 1/2 in.	Rp 1,650
- 10 kg Bangka sand	Rp 21,000
- 1 Kg $KMnO_4$	Rp 4,000

- 1 kg rubber seal (30 cm)	Rp 1,500
- 2 m Robber hose (1/2 in.)	Rp 1,200
- 24 nuts and bolts	Rp 2,400
- Sopporting arms	Rp 17,500
- The working cost	Rp 20,000
	=========
Sub Total	Rp 99,250

B. Operation and Maintenance Cost

During the operation and maintenance the washing and sand replacement process is needed. A satisfactory washing is done after 3 months of usage, where for every washing, 200 liter of water is needed. Therefore the amount of rinsing water needed during the economical life time is :

$$\frac{2 \text{ years} \times 12 \text{ month/year}}{3 \text{ months}} \times 200 \text{ l} = 1600 \text{ l}$$

Because the rinsing water could be use from the raw water or the production water, there are no added cost for the rinsing water. The work cost for each washing is Rp 1,000. The washing is done 4 times/year, so the washing cost = 4 x 2 x Rp 1,000 = Rp 8,000.

C. The total cost is = Rp 99,250 + Rp 8,000

= Rp 107,250

Unit cost = Rp 107,250 / 1,314,000 l

= Rp 0,081 / liter

$= \text{Rp } 81 \text{ /m}^3$

The water cost for each family (consisted of 5 people) can be calculated as follows :

$= \text{Rp } 81 \text{ /m}^3 \times 5 \text{ people/family} \times 0{,}06 \text{ m}^3\text{/per/day}$

$= \text{Rp } 24{,}3$

The results of this cost analysis shows that this model is economicaly profitable, because the cost that has to be spent by each family (of 5 people) each day is only Rp 24,3. (*Note : 1 US $ = Rp. 1,775,00)*

CONCLUSIONS

- Generally, by the result of the experiment and the research analysis in the laboratory and the field it can be concluded that the activated dry sand filter is an efective alternatif for the treatment of drinking water from sources such as the shallow well, to improve the quality of the water physically and chemically.

  Those fact could be observed in the location where the model was applied. The wells in that area were useless, but by utilizing the activated dry sand filter the water could then meet the quality standard of drinking water.

- From the economical point of view, the cost of water treatment using this apparatus is inexpensive, i.e :

  Rp 81 /m³ or Rp 24.30 /family*)/day

  **) one family consist of 5 persons*

As a comparation the price of water from The Bandung Water Supply Company PDAM in Bandung is Rp 140 /m³.

- The efficiency of the activated dry sand filter is depend on :
  1. Loading, which are consisted of :
     * The concentration of raw water (Co)
     * The flow capacity per unit processing area (Q/A)
  2. The sand filter thickness (h)

  In the water treatment process, the most important factors are the raw water concentration and the quality standard for drinking water, while efficiency is only a target. Based on those facts, it can be conclude that for the treatment of raw water the treatment efficiency does not need to be 100 %, most importantly is that the quality standard for drinking water is fulfilled. If the raw water concentration is known, the efficiency of the treatment could then be determine, based on the model's characteristics the flow capacity per unit processing area for a certain thickness also could be determine. Eventually the dimension of the model needed for the water treatment with the desired capacity could be calculated.

- From the results of the study it was also concluded that the activated dry sand filter could have an influenced on :
  * Raising the DO (Dissolved Oxygen)
  * Raising the pH
  * Reducing the color of water

RECOMMENDATIONS

Raw water found in nature varies greatly, and its quality influenced the kind of treatment that needed to be done. Before the activated dry sand filter could be applied properly for the treatment of drinking water, first of all a certain research on the quality of raw water need to be done. Because not all kind of raw water could be effectively treated, even though its iron and manganese content is high enough. Several other components contained in the raw water could reduce the effectivity of the activated dry sand filter, those components are called "distrupting components".

The distrupting components that are commonly found are :

a. Bicarbonate (HCO_3^-)

The activated dry sand filter could effectively treated raw water with a bicarbonate content lower than 500 mg/l. For raw water with a bicarbonate content higher than 500 mg/l, a pre treatment is needed which is in the form of adding in chlorine. The amount of chlorine needed to be added is equals to its Chlor Binding Ability (CBA). Therefore an analysis of the raw water's CBA needed to be done.

b. Manganese organic

Manganese organic is the manganese ion which reacted with organical compounds and form a bond. Natural water which is usually contain manganese organic is water from swamp coastal region. To treat raw water containing manganese organic a pre-treatment unit is needed to eliminate the organic matter. Treatment unit which is generally applied to eliminate organic matter is chlorination with the use of chlorine.

The reduction of iron and manganese is closely related to the acidity (pH). The reduction process will proceed effectively in the pH higher than 8. From the experiment it can be shown that on the pH of about 7 (6,6 - 6,8) the activated dry sand filter is relatively effective in reducing the iron and manganese content.

To ensure the safety of drinking water, beside considering the physical and chemical quality, its bacteriological quality also needed to be considered. The improvement of bacteriological quality generally could be done with the simplest methode, which is by boiling it first before drinking.

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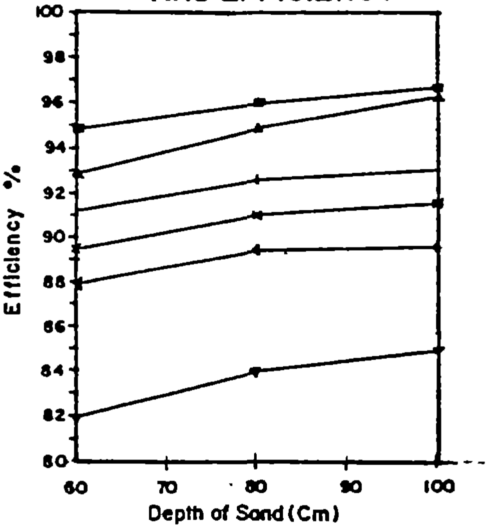
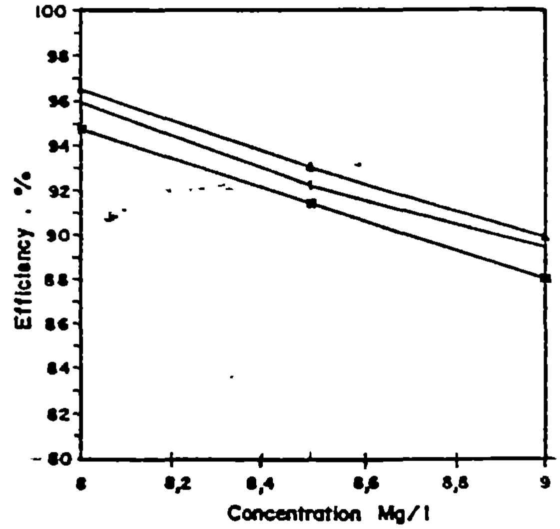
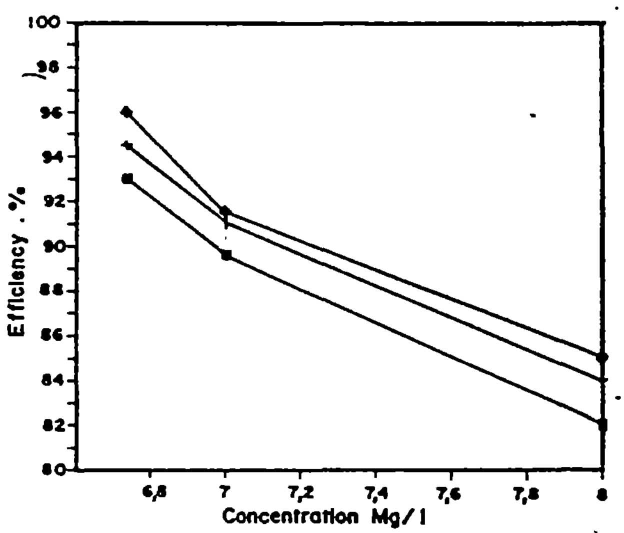
CURVE : 1
DEPTH OF SAND
AND EFFICIENCY



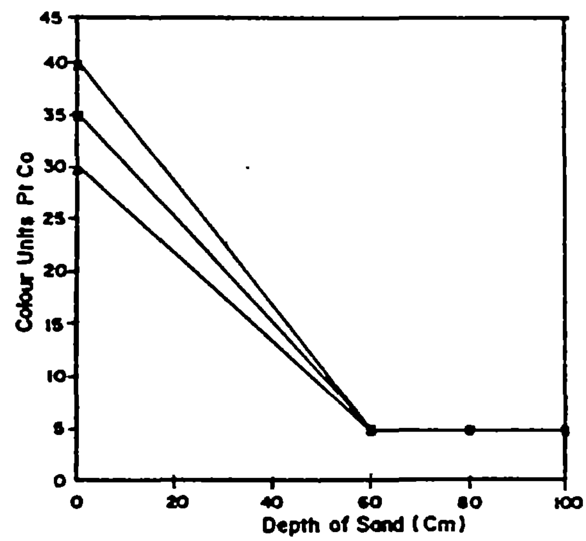
CURVE : 2
CONCENTRATION Fe
AND EFFICIENCY



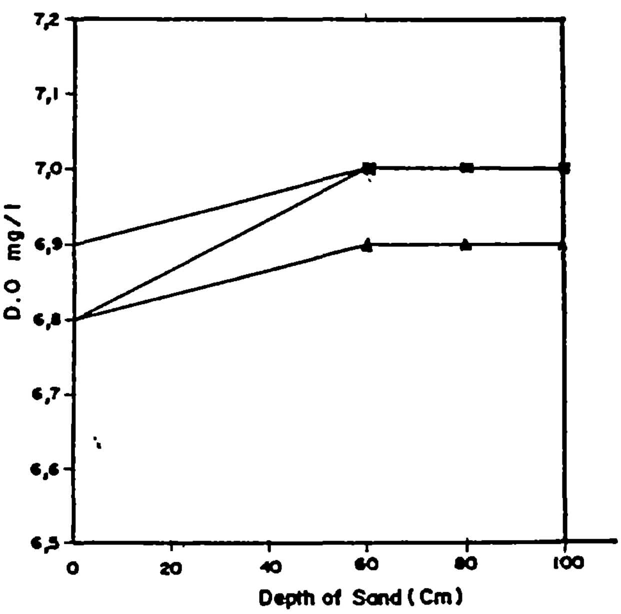
CURVE : 3
CONCENTRATION Mn AND EFFICIENCY



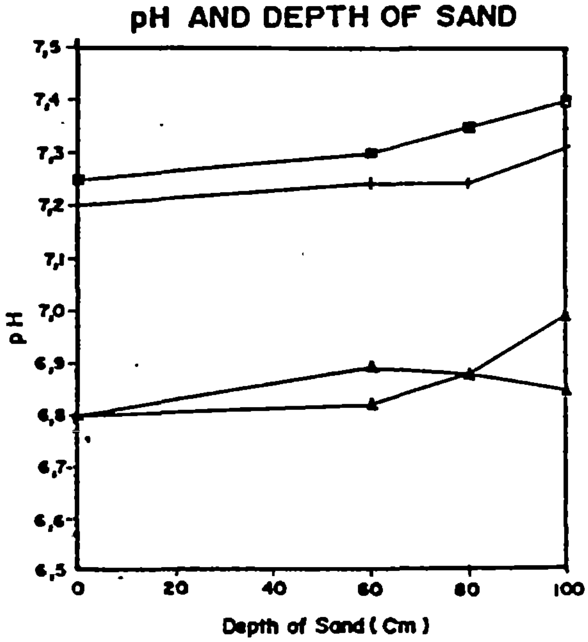
CURVE : 4
COLOUR AND DEPTH SAND



CURVE : 5
D.O AND DEPTH OF SAND



CURVE : 6
pH AND DEPTH OF SAND



WATER EXAMINATION AT DESA SEKELIMUS RT 03/RW 04 BANDUNG
24 Desember 1988

Parametes	Units	Raw Water	After Filtration
Colour	Units Pt Co	20	5
Turbidity	mg/l Sio O2	121	7
Elect Conductance	U mhos/cm	786	731
pH	-	6,6	7,0
Ca	mg/l	54,6	48,30
Mg	mg/l	25	25
Fe	mg/l	1,60	0,00
Mn	mg/l	1,00	0,00
Co2	mg/l	47	38
Co2 agresive	mg/l	non agressive	non agressive
Organic Matter	mg/l KMnO4	12,70	9,3
HCO3	mg/l	448	415
So4	mg/l	20	18
Cl	mg/l	65,30	47,80
Total Hardness	G	13,42	13,,24

Source : Laboratory of Environmental Engineering TL.- ITB, 1989

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