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Filter ZeRAK for Decreasing Water Hardness and Coliform

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Abstract

Salah satu persyaratan kimia yang harus terpenuhi oleh air minum adalah kesadahan. Air dengan kesadahan tinggi sangat berbahaya bagi kesehatan manusia khususnya ginjal. Begitu pula persyaratan bakteriologis. Angka MPN coliform merupakan indikator kualitas air yang terkait dengan cemaran tinja. Tujuan penelitian ini untuk menurunkan kesadahan dan coliform air sumur gali di Desa Jimbung, Kalikotes, Klaten, dengan membuat filter penyaring yang terdiri dari zeolit, resin, klorin dan arang aktif, melalui eksperimen dengan pre-test dan post-test desain. Sampel penelitian adalah 45 sumur dengan perpipaan yang ada desa tersebut. Hasil penelitian menunjukkan bahwa kesadahan rata-rata sebelum dilakukan penyaringan sebesar 270 mg/liter, dan setelah penyaringan turun menjadi 44 mg/liter (84%). Sementara untuk coliform, sebelum penyaringan berkisar antara 111 hingga 1898 MPN per 100 ml, dan setelah penyaringan turun menjadi kisaran 0 s/d 7 MPN. Secara statistik perbedaan hasil pengukuran tersebut signifikan (kedua nilai p <0,001), sehingga dapat disimpulkan bahwa filter ZeRak yang digunakan efektif untuk menurunkan kesadahan dan coliform.

***Keywords**: penyaringan air, zeolit, resin, arang aktif, kesadahan, coliform, air sumur*

Intisari

One of chemical requirement for drinking water is hardness. Water with high level hardness is very dangerous for human health, specifically for kidneys. MPN coliform as one of bacteriological requirements for water quality is an indicator for excreta pollution. The aim of the study was to decrease water hardness and coliform in water wells of Jimbung Villages in Kalikotes, Klaten by installing ZeRAK filter, which consists of zeolite, resin, chlorine and activated charcoal. The study was an experiment with pre-test and post-test design. As a study sample were 45 wells that were connected with plumbing in that village. The results show that before the filtration, the average of water hardness was 270 mg/l, while post-filtration it was 44 mg/l (84%). Coliform pre-filtration were in a range between 111 and 1898 MPN per 100 ml, and after treatment they were between 0 and 7 MPN. Statistically, the differences are significant (both p-values <0,001). To conclude, ZeRAK filter used in this study is effective to decrease water hardness and coliform.

***Kata Kunci**: water filtration, zeolite, resin, activated charcoal, water hardness, coliform, well water*

BACKGROUND

Water is a basic and important need for human living. To fulfill the need, various facilities for clean water supply are provided, such as rain water collection, dig well, hand water pump, public potable water company, etc. In order to meet water needs, there are still many Indonesian people who depend on well water as the source of clean water and potable water. In some areas, those well waters contain very high levels of hardness that dangerous for the health of people who consume it.

One of indicators of high water hardness is if it is boiled will produce sediment at the bottom of the pot and crust on the wall. This sediment is a form of metal particle that will persistently exist inside the human body. If this water is consumed, the sediment will settle in the kidney and gradually will become bigger which can lead to a condition that is called kidney failure [1)].

The usage of very high levels of water hardness can also affect technical aspects that are related with economic issues, e.g. rusty utensils made of ferrum, soap that is not easily foamed, and sediment inside containers used for processing the water.

Based on the preliminary study with four wells owned by Kalikotes inhabitants, the water hardness was measured as follows: well I 416 mg/l, well II 282

mg/l, well III 334 mg/, well IV 355,5 mg/l. According to Chandra [6], water with hardness exceeds 300 mg/l is categorized extremely hard water. Water with hardness above 300 mg/l, if it is continuously consumed, will defect human kidneys [3]. Other than that, such hard water if boiled will yield white sediment that will settle in the kidney if consumed. In Jimbung Village of Kalikotes, three people had kidney disturbance and kidney failure. Among the community, there were also found death caused by kidney failure.

The well water hardness in Jimbung should be solved so that the community is prevented from getting the risk of kidney failure because of the extremely high water hardness they consumed. The wells that are used by the community are the shallow ones. Therefore, they are not bacteriologically safe, as well. Even, in the rainy season, water in some wells looks turbid because of the seepage from ground water. Up to now, the water is only processed by boiling. However, the boiling itself yields white sediment that also dangerous if it is drunk.

One of the solutions is by applying water filtration using filter that contain resin as ion exchange because it decrease water hardness. By treating the water by using ZeRAK filter that made of zeolite, resin, chlorine and activated charcoal, excessive hardness concentration that generate sediment in kidney will be diminished, even it will disappear.

Moreover, the MPN coliform in the water will also be decreased and so that can safely consumed by people. Therefore, by applying this filtration device, the community will be spared from getting risk of kidney disturbance because of consuming hard water and from infection diseases because of drinking MPN coliform water. Beside, aesthetically, potable water which is free of sediment is more convenient to be consumed.

METHODS

This study was a quasi experiment which employed pre-test post-test group design. The total population of wells in Jimbung Village is 45, and they all were used as study samples. The data were analyzed by using independent t-test at 95% level of significance. The study was conducted between 19th July and 19th September 2018. The water hardnesses were examined on site by using a hardness kit, while the MPN coliform were examined at the Laboratory of the Polytechnic of Health of Yogyakarta. The pre-test data were taken prior to ZeRAK filtration and the post-test data were taken afterward.

RESULTS

Table 1 shows that the average of water hardness from all the wells before the filtration is 270 mg/l, and the average of post data is 44 mg/l. So that, by using ZeRAK filter, the average of water hardness reduction is 226 mg/l or 84%. Meanwhile, based on Table 2, Coliform before treatment with ZeRAK filter is between 111 and ≥1898 MPN, and after the treatment is decreased only between 0-7 MPN.

DISCUSSION

This study applied the filtration to all kinds of well, i.e. drilled well and dig well, as long as they use water pump and were channeled by using plumbing system. This is to enable the filtration process of ZeRAK. Water which will be treated were collected from the faucet of piping outlet. The faucet was connected with hose and the water were then channeled to ZeRAK filter to be processed. Water sample for pre-test measurement of hardness and coliform were obtained before the filtering process, and for post-test measurement were taken after the treatment.

The existing water treatment is only by boiling the water for cooking needs and the provision of potable water. After the water is boiled, it looks turbid because of the lime sediment contained in the hardwater. The study also observed that many water faucets used by the villagers are rotten and clogged with crust. The observation also saw that the pipes

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for water distribution are also clogged, closet and bathroom tiles are thickly crusted enough and therefore is difficult to be scrapped. Theoretically, problems in economical aspects, among others are the rusty of iron-made devices and utensils, low effectivity of soap, the increase use of fuel for water boiling, not efficient, can blow-up kettle, high cost production for industries which utilize the hard water, and generate crusts inside the processing pots [7].

Tabel 1.
Water hardness, before and after ZeRAK filtration

Sample no	Water hardness (mg/l)		
	Pre-test	Post-test	Reduction
1	249	36	213
2	252	33	219
3	243	30	213
4	222	45	177
5	264	21	243
6	354	84	270
7	267	39	228
8	237	48	189
9	243	36	207
10	249	54	195
11	276	57	219
12	354	66	288
13	246	30	216
14	348	54	294
15	336	21	315
16	225	27	198
17	204	21	183
18	327	27	300
19	300	30	270
20	207	30	177
21	228	42	186
22	210	60	150
23	270	60	210
24	330	66	264
25	270	57	213
26	300	63	237
27	267	48	219
28	231	36	195
29	234	54	180
30	276	57	219
31	354	66	288
32	246	30	216
33	348	54	294
34	336	21	315
35	225	27	198
36	213	21	192
37	327	27	300
38	300	30	270
39	177	30	147
40	228	42	186
41	240	60	180
42	270	60	210
43	303	66	237
44	270	57	213
45	300	63	237
Average	270	44	226

The observation of Jimbung Villagers' cooking utensils and eateries revealed that drinking glasses have feculent surfaces, dishes look dirty, cooking pots have thick white-brownish crust. Those are manifestations of high level water hardness existing in the well water used by Jimbung's people.

Water hardness concentration prior to filtration was 270 mg/l in average, and it is categorized as very high. This measurement is supported by the environmental condition observed as well as the impacts. Jimbung Village is part of a limestone area in Klaten, so that it contributes to the high level of water hardness. For decades, before drinking the water, people used to boil and precipitate their well water.

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Tabel 2.
Coliform, before and after ZeRAK filtration

Sample no	Coliform (MPN)		
	Pre-test	Post-test	Reduction
1	≥1898	0	≥1898
2	494	0	494
3	233	0	233
4	≥1898	2	≥1898
5	≥1898	0	≥1898
6	≥1898	0	≥1898
7	≥1898	4	≥1898
8	494	0	494
9	294	0	294
10	190	0	190
11	494	0	494
12	≥1898	7	≥1898
13	≥1898	0	≥1898
14	233	0	233
15	111	0	111
16	≥1898	4	≥1898
17	130	0	130
18	190	0	190
19	≥1898	4	≥1898
20	294	0	294
21	≥1898	4	≥1898
22	188	0	188
23	390	0	390
24	294	0	294
25	190	0	190
26	494	0	494
27	≥1898	0	≥1898
28	≥1898	7	≥1898
29	233	0	233
30	≥1898	7	≥1898
31	≥1898	0	≥1898
32	≥1898	7	≥1898
33	190	0	190
34	≥1898	0	≥1898
35	294	0	294

Tabel 2. (continued)
Coliform, before and after ZeRAK filtration

Sample no	Water hardness (mg/l)		
	Pre-test	Post-test	Reduction
36	≥1898	7	≥1898
37	≥1898	0	≥1898
38	390	0	390
39	190	0	190
40	≥1898	0	≥1898
41	294	0	294
42	≥1898	7	≥1898
43	≥1898	0	≥1898
44	390	0	390
45	190	0	190

Nonetheless, boiling the water still leaving particles which are not precipitated completely and if they are consumed will then be settled in kidney. By boiling the water there are still particles left that will not settled perfectly and will enter the body which will then occur deposition in the kidneys.

According to Said [19] water containing hardness is not safe if only heating is done, because salt or kation that causes hardness can not be lost only by heating. Hardness can be eliminated by processing one of them with exchange ions using resin. From this study results, the average decrease of hardness was 84% with a discharge of 1 l/30 seconds, i.e. from an average of 270 mg/l to an average of 44 mg/lt. The post-test measurement indicates that the hardness level can be categorized as low level. Based on observations, after filtering and boiling, there are no more floating limestone deposits and the water looks clear.

The decrease in hardness is in direct contact between the resin and the raw water containing hardness, so that the ion exchange process occurs. The ion exchange process that occurs is Calcium ions and Magnesium ions in hard water are exchanged with ions in the resin. The resin contains positive ions, namely Na + which is bound to the acid functional group, namely SO3-, so

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that when hard water flows into the resin, the resin will release Na + ions to replace Ca2 + and Mg2 + ions in hard water [19]. The reaction is as follows:

$$2RSO_3Na + Ca^{2+} \rightarrow (RSO_3)_2Ca + 2Na^+$$

$$2RSO_3Na + Mg^{2+} \rightarrow (RSO_3)_2Mg + 2Na^+$$

The reduction of hardness with resin ions exchange method is one of the efforts to improve the quality of raw water in order to make it safe to consume. The sediment when used for bathing, make the skin becomes dry and scaly, besides it is still at risk of causing kidney disease disorders in the people who consume.

On the other hand, the condition of >200 levels is very bad, so it is still very dangerous to consume. The filtration process by using ZeRAK filter is able to lower the concentration from 270 mg/l to 44 mg/l, i.e. there is an average reduction of 226 mg/l (84%). These results are categorized as the soft level, which means that the water is relatively safe, because it is below the threshold of <50 mg/l. Based on that, this filter can be used in the community whose the hardness of the water source is fairly high.

However, ZeRAK filter still needs further research to lower water hardness which at higher level, higher discharge, as well as to increase its effectiveness based on the volume of water in the filter.

From the results of coliform examination, it is shown that before filtration using ZeRAK filter, the well water in Jimbung Village already had positive coliform. Based on observations, the wells in that village are included shallow ones that only has one meter high. This condition indicates that the well water used is surface water which is derived from groundwater evaporation. That characterristic makes the coliform content of well water in Jimbung area is quite high.

In addition to the well water that is sourced from groundwater, physically the construction of wells in Jimbung area majority do not fulfill requirements, such as the wells' wall are not waterproof, the floors are not waterproof, and the contour of the sewage line do not in good condition. Therefore it exacerbates the coliform contamination.

The high coliform concentration in water wells needs serious handling to protect residents from the risk of water borne diseases. In order to be safely consumed and not to harm the health of the villagers, the well water should prior be processed. Based on the results of well water filtration using ZeRAK filter with a debit of 1 liter/30 seconds, was able to lower coliform in a range of 0-7 MPN coliform/liter. The corresponding t-test to analyse the data obtained p value less than 0,001 which menas that there is a significant difference between MPN coli-form before and after filtration.

The decrease in the number of MPN Coliform germs is related to disinfection mechanism by chlor contained in ZeRAK filters. The bacteria contained in the water of the digging well is filtered through a series of filters inside ZeRAK whose one component is chlor powder. Chlor powder that is mixed with sand serves as a filter as well as a disinfectant that kills bacteria in the water.

A previous study by Andita [3] stated that there is a variation in the exposure time of aluminum solar disinfection tubs to the decrease of *E. coli* in drinking water supply and the exposure time of six hours has the highest average decrease of the bacteria in well water.

According to Soemirat [21], Coliform is not a pathogenic bacteria that harms public health, but it is an indicator that water is already polluted by pathogenic bacteria. According to MoH in the decree number 416/Menkes/Per/IX/1990, coliform bacteria that qualify for safe well water are <50 MPN.

After being filtered by ZeRAK, the coliform number becomes below 10 MPN, which means it meets the requirements. Thus, ZeRAK filter may play role as a simple water treatment alternative that is able to lower coliform in the water supply system. However, from the examination results, the filtered water are smelled chlorine that might lead the community feel less comfortable to consume. Therefore, it is necessary to con-

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duct further research to eliminate the smell. The following research shouls also study public acceptances of ZeRAK filters and calculate its economic value.

CONCLUSION

Based on the results, it can be concluded that: 1) the average of well water hardness before and after treated by ZeRAK filter was 270 mg/l and 40 mg/l, therefore the filter is able reduce 84% of water hardness, 2) the coliform of well water before and after treated by ZeRAK filter was between 111 and ≥1898 MPN and between 0-7 MPN, 3) The average difference of water hardness and coliform between pre-treatment and post-treatment with ZeRAK filter is significant.

RECOMMENDATION

People of Jimbung Village are advised to utilize ZeRAK filter in order to reduce the water hardness before it used for cooking and drinking purposes. The local government of Jimbung Village is urged to socialize the importance of water hardness reduction to prevent kidney-related health problems. The Health Office of Klaten Regency is advised to always monitor the quality of drinking water used by the community in their service areas for household purposes, in terms of water hardness dan coliform.

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