Journal of Mechanical Engineering

by Surya Hermawan

Brackish Water Treatment with Local Filter Media and Reverse Osmosis Using Application of Internet of Things Technology

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ABSTRACT

Global clean water crisis is affecting more than 40% population and still increasing. As an archipelago state with large coastal area, Indonesia is however facing the common issue with the clean water shortage. There are still lack of access to clean water and water treatment plant for the community in the coastal area to fulfill their daily needs and drinking water as most water source is brackish water with higher salinity than fresh water. Hence further treatment is required to obtain the clean water and safe for daily consumption. The objectives of this research work are to determine suitable local material for water treatment and alternatively by using reverse osmosis equipment which is expected to reduce salinity of treated water. As methodology used in this research, a physical treatment experiment on the brackish water is conducted through a selected local filter media and by using reverse osmosis equipment with the assistance of internet of thing technology. The research work outcomes demonstrate that treated water by filtering has indicated a clear physical appearance and odorless but no significant improvement on pH and about 3,67% reduction on TDS value and 7.0% on EC value. On the other side, the treatment through reverse osmosis method is showing better result with significant improvement with 99.5% TDS and EC value which can't be achieved by filtering treatment.

Keywords: *Clean water crisis; brackish water; local filter media; reverse osmosis; internet of things*

ISSN 1823- 5514, eISSN 2550-164X

Received for review: 2022-xx-xx
Accepted for publication: 2022-xx-xx
Published: 2022-xx-xx

Introduction

Water is one of main basic human needs and clean water demand is constantly increasing especially in Indonesia. This is not only for household purpose but also to fulfil the other activities such as industrial or production activities which requires a significant amount of clean water. As the population and demand are increasing while the water cycle according to hydrology is relatively constant, it will lead in the future to clean water crisis [1]. According to Badan Pusat Statistik Indonesia (Statistics Indonesia), access to eligible drinking water source has reached at 90,21% while the target set by Sustainable Development Goals (SDG) is 100% accessible eligible drinking water source globally in 2030. On the other side, the clean water source availability from one to the other area is not at the same level [2].

Lack of access to clean water is the main issue for the community in the rural and coastal area as they depend on the natural water resources such as groundwater for their daily needs and drinking water. The groundwater quality in this area is degrading from time to time because of ecosystem change and the contamination in groundwater itself [3]. Hence it will bring socio-economic impact to the community such as health issue and cost increasing for clean water supply.

This research work took place in Sidoarjo regency, East Java Indonesia. Sidoarjo regency is river delta area and located between the Kalimas and Porong river. Sidoarjo area is historically vulnerable to the nature disaster, e.g., flooding and typhoon or tornado. Environmental contamination from the local industrial area is also contributing to the clean water resources availability for the community daily needs in farming and their daily consumption [4]. Hence a proper water treatment needs to be developed in this research work to overcome the clean water resources availability issue.

The challenge in this work is that the only available water resource sample is brackish water from household wells with high salinity [5,6,7,8]. High salinity pollution is mainly caused by backflow from irrigated areas which send high salinity from farming areas in the village to surface waters. The water sample is obtained from two villages, Tegal Sari and Tanjung Sari, in Jabon District, Sidoarjo Regency. Therefore, clean water is bought and supplied periodically by truck to the community to fulfil their daily household needs. As brackish water is available abundantly in this area, it has promising alternative solution to help the community issue with clean water supply. Brackish water treatment method has been developed to overcome the clean water supply in some areas in Indonesia to overcome the clean water supply issue [9]. The research goal is to provide the brackish water treatment by selecting local suitable material to clarify the water, including

Lamongan sand, brick, which consists of silica sand, sponge, alum, charcoal, active carbon, kaolin, and zeolite.

The objective of this research work is to find the best combination of filtration method by selecting local suitable material and reverse osmosis with the help of internet of things to produce clean water from brackish water. It is expected that the research results can be used as a reference for the next research project improvement and as a solution for the regional government to overcome clean water crisis. To measure water quality, some parameters i.e., pH (Power of Hydrogen), TDS (Total Dissolved Solids), EC (Electrical Conductivity), odour dan colour of the water sample will be tested to compare the result before and after treatment.

Material and Research Methodology

This research was carried out by experimental research which utilized physical method to figure out the best combination from the treatment of brackish water in site location. The material is collected from local material, including This. sand, pumice, carbon active, kaolin, coconut shell charcoal, red brick, bio ring, zeolite, clamshell and 10-micron filter were used in the previous experiment. Used material in this experiment are silica sand, alum, active carbon, kaolin, charcoal, zeolite, sponge, and 10-micron filter. Mobile technology with internet of thing will be applied in this water treatment equipment. This equipment is powered by solar cell and water flow can be remotely controlled by smartphone. Hence it will be easier for the community to monitor the treatment progress.

Material

Silica Sand

Silica sand, known as quartz sand, is a quartz mineral which has a high content of silicon dioxide (SiO_2) at approximately 99.7%. It consists hard, durable, and dense grains which has high degradation resistance as well. Silica sand is commonly used in water filtration system. As silica sand has the capability to retain the precipitates or impurities in the water and highly effective filter media, it is expected that silica sand can remove the sludge contained in brackish water [10].

Alum

Alum is chemical compound which is a hydrated aluminium sulphate salt and found in the white crystalline form. Potassium alum, known as potash alum, is used commonly as flocculant agent in the other water treatment e.g., grey water [11]. It can coagulate the water impurities so that the impurities can be removed easily. With its characteristic as flocculant_agent, it is not only used in water treatment, but it_is also utilized in another industrial sector, i.e., medicine, food preparation, and textile industry. Alum should be added in sufficient amount, otherwise the treated water is not safe for consumption.

Active Carbon

Active carbon has a high surface area, homogenic pore size, chemical inert, and stability as physical property. With the characteristic above, active carbon has the capability to remove odour and colour which is caused by the natural organic compound material in water by adsorption and improve the water taste [12,13]. However, active carbon doesn't have ability to remove both coarse and fine impurities in the water.

Sponge

Sponge is the porous synthetic material which can absorb water and has the good aeration capability. It is widely available, simple, and cost effective. Sponge is used as basic physical or mechanical filtration and has the function to separate the suspended solid particle in water by absorbing it in the pore. However, sponge has limited capability to remove the dissolved impurities and can be cleaned regularly. The recent studies showed that there are sponge and fibre material development as filtration and absorption material for chemical compound removal such as ammonia removal from groundwater and oil removal [14,15,16]. One of the recent developments of graphene oxide- based sponge which is applicable for textile, paint, printing, and food industries to remove the impurities such as dye material [17].

Kaolin

Kaolin or kaolinite is a type of clay material with the chemical formula $Al_2O_3.2SiO_2.2H_2O$ which is one type of primary clay. It can remove toxic pollutant from the water by adsorption. Like active carbon, it has high surface area and stability as physical property. Kaolin is a highly non-plastic adsorbent so that the shrinkage and dry strength are the lowest [18]. This filter also has a weakness in filtering water, which is not able to hold fine dirt or coarse dirt.

Charcoal

Shell charcoal is charcoal that comes from coconut shells. The shell is burned until it becomes charcoal. As an alternative, charcoal from wood burning can also be used. In addition to absorbing chemicals that pollute water, coconut shell charcoal in the form of granules can also hold solid objects that pollute the water [19,20]. Shell charcoal has a weakness in filtering water, it can't make the initially turbid water clear and can't filter the impurities contained in brackish water. In terms of shell charcoal filter maintenance, it takes long time.

Zeolite

Zeolite is a hydrated alumina-silicate chemical compound with sodium, potassium, and barium cations. Zeolite also has molecular-sized pores so that it can separate or filter molecules of a certain size. Natural zeolite can naturally be formed from volcanic rocks, as well as sedimentary rocks [21]. Zeolites have a negative charge due to the presence of aluminum atoms in them. This negative charge causes zeolite to bind cations in water, Fe, Al, Ca, and Mg which are generally found in groundwater. By flowing raw water in the zeolite filter, the cations will be bound by the zeolite which has a negative charge. In this research, zeolite is expected to be able to purify and treat brackish water so that it can be better in terms of color, odor, and content.

Reverse Osmosis (RO)

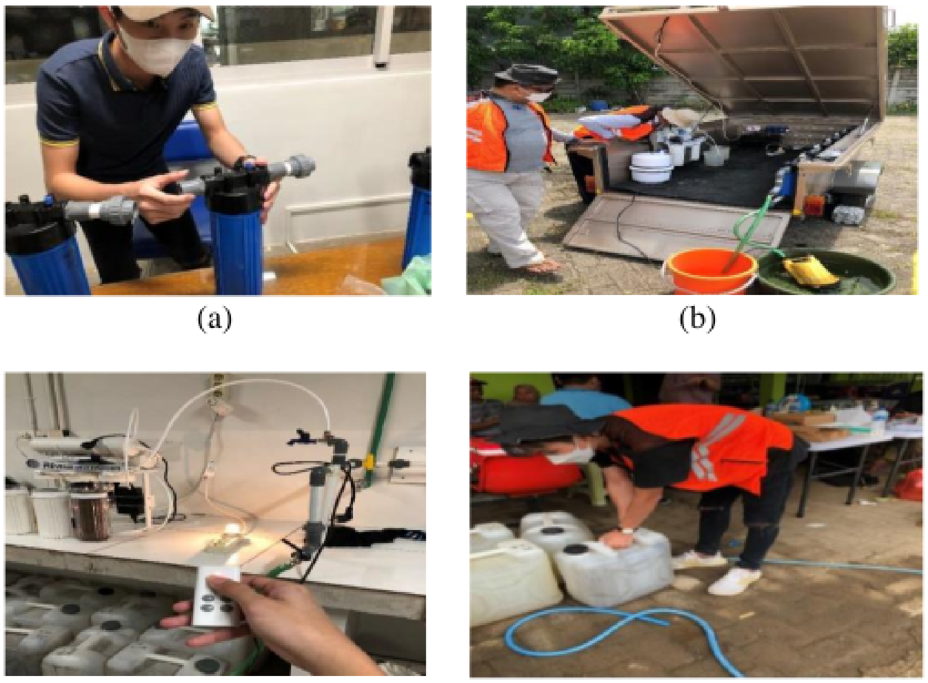
Reverse osmosis is the most effective separation technology which is used in some industrial area for water treatment e.g., sea water desalination, brackish water treatment and wastewater treatment [22,23,24]. Reverse osmosis is water treatment process which is applying water pressure through semi permeable membrane to remove dissolved inorganic contaminants from water. These dissolved inorganic contaminants are fluoride, chlorine, nitrates, sulphate, pesticides, etc. [25]. A pre-treatment process is needed to remove the solid impurities so that it will not damage the membrane and shorten the usage time. Periodical cleaning for fouling removal on the membrane must be conducted between 6 - 12 months to improve the reverse osmosis performance.

Mobile Hanger

As the combination of filtration material and reverse osmosis is expected to be used in remote area with difficult access, these will be assembled in a mobile hanger and can be towed by a car or motorcycle with towbar [26]. The assembly of the filtration material and reverse osmosis unit has taken place in hydrology laboratory at Petra Christian University. The mobile hanger is equipped with solar panel for alternative energy source to activate the equipment.

Research Methodology

Research methodology, which is applied experimental research, including literature study, and followed by a case study. Related information and data, which are related to brackish water e.g., properties of brackish water, treatment method and recent research in brackish water treatment, are collected. This will serve as basis for this research. Physical experiment on brackish water treatment will be applied in the case study by selecting the suitable local material as filter media. This local material will be used in the filtration and combined with semi permeable membrane in reverse osmosis equipment.



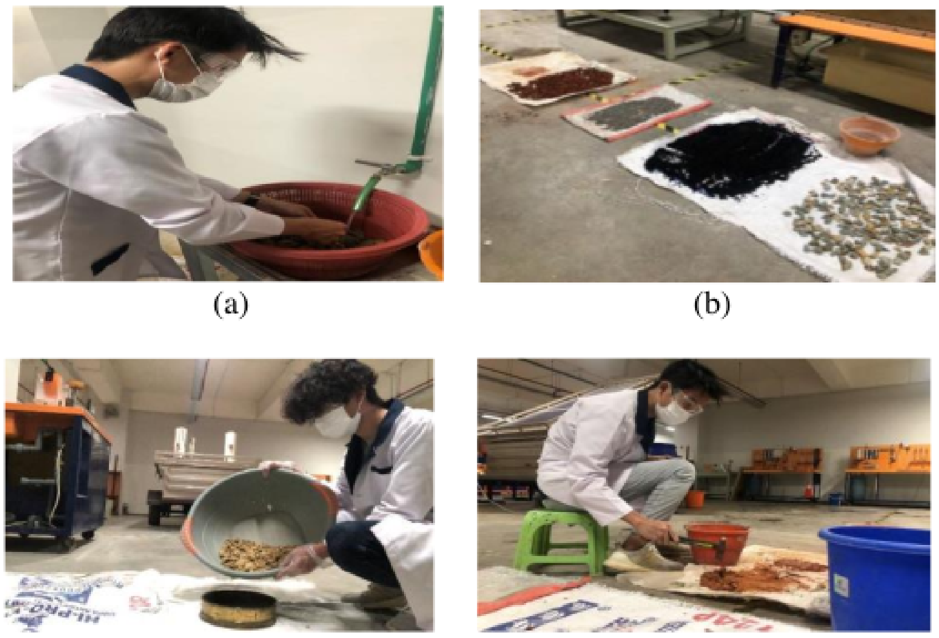
(a) (b)

(b) (d)

Figure 1: Water treatment equipment. Assembly of filter media into the filter module in mobile hanger and water sample collection from the research area

The above selected filter media and its assembly as filter module has taken place in the laboratory (Fig. 1.a). This will be combined with reverse osmosis equipment and assembled in the mobile hanger as complete mobile treatment unit (Fig. 1.b). Internet of things [27,28] will be applied as well in the case study by using a remote control to activate the mobile treatment unit (Fig. 1.c). Data collecting in this research will be started as the mobile treatment unit is ready to be operated. Water sample is collected from two villages, Tegal Sari and Kupang, in Jabon District, Sidoarjo Regency (Fig. 1.d).

Filter media, which is used in this research, will be prepared accordingly in three main phases, cleaning, drying and mechanical preparation phase. In the first phase, filter media will be washed to eliminate dirt and other contaminant (Fig. 2.a). Once the filter media is cleaned by washing, it will be dried. It takes about 1 or 2 days in the drying phase (Fig. 2.b). Some filter media is needed to be further prepared by screening (Fig. 2.c) and crushing (Fig. 2.d)



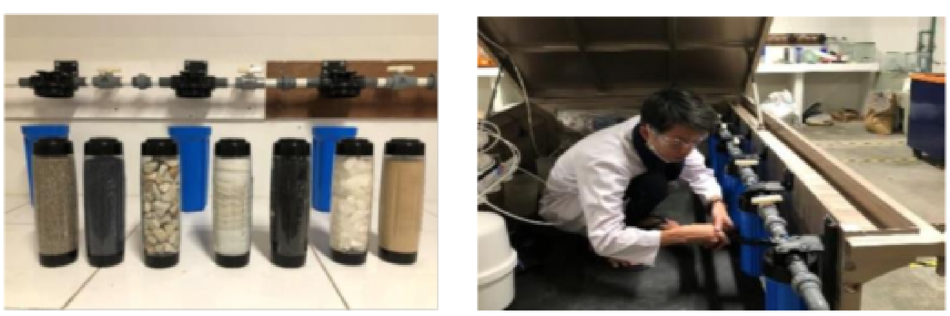
(a) (b)

(c) (d)

Figure 2: Filter media treatment. Washing, drying, screening, and crushing of filter media

Filter Media Assembly

Once the filter media is prepared, filter media will be filled into the filter module (see Fig. 3.a, d). Filter module with each filter media will be assembled in mobile hanger (see Fig. 3.b). Brackish water sample will be pumped into the filter module. Treated brackish water from the filtration will be collected and analysed further for its quality indicator. Water quality parameter i.e., pH, TDS, EC, odour, and colour will be observed and measured (see Fig. 3.c).



(a) (b)

(c)

(d)

Figure 3: Filter module application. Brackish water sample will be flowed into the filter module and measurement of water quality parameter

Brackish water is flowing through selected filter material, silica sand, active carbon, zeolite, sponge, charcoal, alum, kaolin. Based on analysis result, collected brackish water sample has the average pH of 7.9, TDS at value 2450 ppm, EC value at 4920 µs/cm. Besides of these quality parameters, it has also odor and turbid in physical form.

Standard water quality parameter used in this experiment is based on WHO guidelines for drinking water quality and Minister of Health Republic of Indonesia Regulation (Peraturan Menteri Kesehatan Republik Indonesia / PERMENKES) No. 492, 2010 which requires that clean water must have an average pH between 6.5 – 8.5, TDS value lower than 500 ppm, EC value lower than 300 µs/cm, odourless and colourless as physical criteria [29,30]. The experiment analysis result from the treated water will be compared with the above quality parameters. There are 4 filter modules which will be used in this experiment. Several filtration combinations will be used to obtain the best filtration result (see. Tab. 1.)

Table 1: Filter module combination

No	Filter module 1	Filter module 2	Filter module 3	Filter module 4
1	Silica sand	-	-	-
2	Alum	-	-	-
3	Kaolin	-	-	-
4	Active carbon	-	-	-
5	Sponge	-	-	-
6	Charcoal	-	-	-
7	Zeolite	-	-	-
8	10-micron filter	-	-	-
9	Alum	Zeolite	Active carbon	Silica sand

10	Alum	Silica sand	Zeolite	Kaolin
11	Alum	Active carbon	10-micron filter	Silica sand
12	Silica sand	Zeolite	10-micron filter	Active carbon
13	Charcoal	Kaolin	Silica sand	Sponge
14	10-micron filter	Silica sand	Active carbon	Kaolin
15	Charcoal	Kaolin	Zeolite	Active carbon
16	10-micron filter	Zeolite	Active carbon	Kaolin
17	Zeolite	Active carbon	10-micron filter	Kaolin
18	Zeolite	Silica sand	10-micron filter	Active carbon
19	Silica sand	Zeolite	Active carbon	10-micron filter
20	Zeolite	Silica sand	10-micron filter	Charcoal
21	Silica sand	Zeolite	Active carbon	10-micron filter
22	Charcoal	Zeolite	Silica sand	10-micron filter
23	Charcoal	Zeolite	Silica sand	Kaolin
24	Zeolite	Charcoal	Silica sand	Kaolin
25	Zeolite	Silica sand	10-micron filter	Sponge
26	Silica sand	Zeolite	Sponge	10-micron filter
27	Sponge	Zeolite	Silica sand	10-micron filter

Result

TDS and EC are the water quality variable to be considered because it is a determining variable in river waters [31]. pH, TDS, EC, will be measured in two sections. First section is the parameter measurement after the filtration through filter modules without reverse osmosis. The second section will be parameter measurement from the treatment result of reverse osmosis. Hence, brackish water treatment effectiveness from filtration and a combination of both filtration and reverse can be evaluated.

Water Quality Parameter after Filtration

The comparison in water quality parameter between before and after treatment from each filter combination in this experiment can be shown in the below figure.

pH

Brackish water sample from both Tegal Sari and Tanjung Sari village has the same average pH value at 7.9. This value complies with Minister of Health Regulation for clean water even the value itself is on the high side. The filtration result shows that increasing in pH value from 7.9 to 8.3 is shown in the experiment number 12 to 15 while there is highest decreasing in pH value from 7.9 to 5.2 which is occurred in experiment number 3. pH value comparison between before and after filtration from each experiment number is shown in Fig. 4.

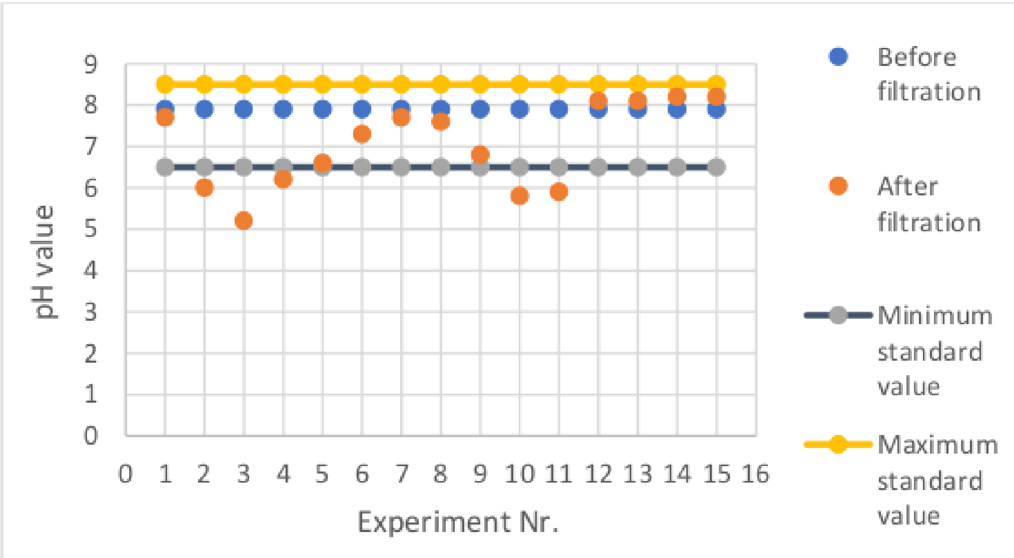


Figure 4: pH value comparison, before and after filtration

Total Dissolved Solid (TDS)

TDS value from brackish water sample is at 2450 ppm which is much higher than the standard value at 500 ppm. In experiment number 13 which its filter module consists of charcoal, kaolin, silica sand and sponge, showed that TDS value has decreased from 2450 ppm to 2360 ppm. An increasing TDS value is shown in experiment number 2, 9, 10 and 11. Experiment result comparison in TDS value can be seen in the Fig. 5.

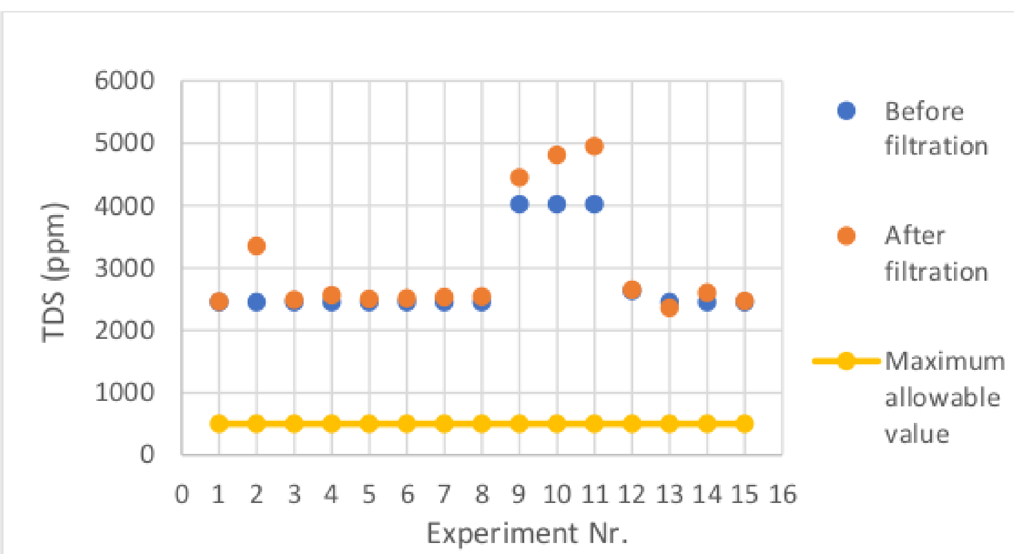


Figure 5: TDS value comparison, before dan after filtration

Electric Conductivity (EC)

Average EC value which is obtained from the water sample is 4920 µs/cm. There are also no significant changes in EC value after filtration. The standard value of clean water EC should be lesser than 300 µs/cm. The result from experiment no. 13 with charcoal, kaolin, silica sand and sponge are showing decreasing EC value from 4920 µs/cm to 4570 µs/cm. However, this result doesn't comply with the quality standard which requires that the treated water should have lesser than 500 µs/cm. Higher EC values are shown in experiments 2, 9, 10, and 11, which has the same tendency as TDS value. There is a relationship between EC and TDS value; the higher the TDS value, the higher the EC value [32]. Experiment result comparison in TDS value can be seen in Fig. 6.

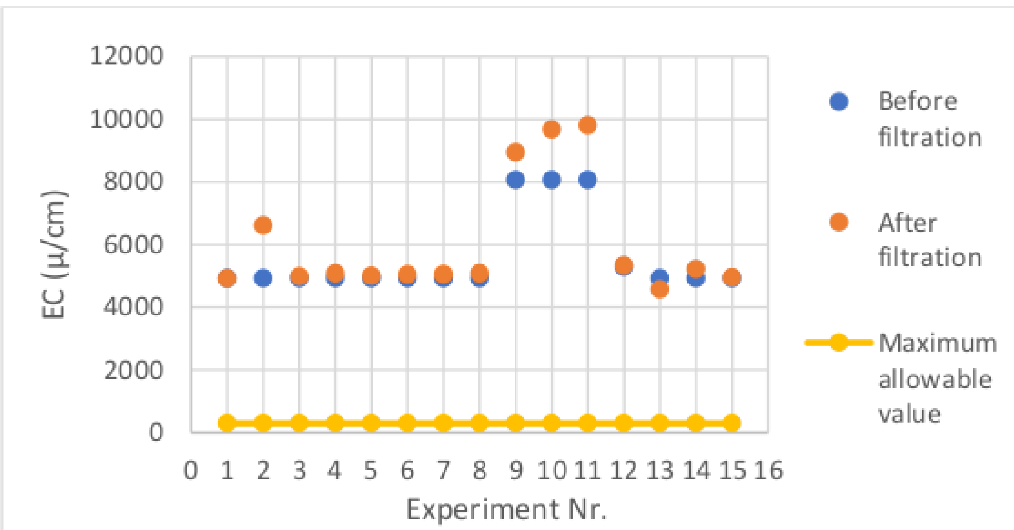


Figure 6: EC value comparison, before and after treatment

Water Quality Parameter after Filtration

As the result from the filtration with selected local material are not effective enough, a reverse osmosis equipment is used to treat brackish water sample. The reverse osmosis unit is equipped with filter module before it goes into reverse osmosis unit. The filter module consists of 10-micron filter, Chlorine Taste Odour (CTO) and Granular Active Carbon (GAC). The brackish water will be pump from 10-micron filter, CTO and GAC respectively as pre-treatment.

In this experiment, brackish water sample will be treated two times with reverse osmosis which the first treated water will be treated again for the second time. The result in Tab. 2. shows the first treatment result. Based on the result in the Tab. 2., TDS and EC value contained in the brackish water can be removed approximately at 95 – 98%while there is increasing in pH value from 8.0 to 8.2.

Table 2: Reverse osmosis first treatment result, before and after

Time	pH		TDS		EC	
(minutes)	Before	After	Before	After	Before	After
5	8,0	8,2	2770	232	5500	467
10	8,0	8,2	2770	247	5500	496
15	8,0	8,2	2770	245	5500	493
20	8,0	8,2	2770	252	5500	500
25	8,0	8,2	2770	250	5500	503
30	8,0	8,2	2770	253	5500	504
35	8,0	8,2	2770	251	5500	505

The second treatment result is shown in the Tab. 3. where TDS and EC value can be reduced further much lesser than the standard clean water quality parameter. pH value shows a little increasing from 8.2 to 8.3 after the second treatment which is not significant.

Table 3: Reverse osmosis second treatment result, before and after

Time	pH		TDS		EC	
(Minutes)	Before	After	Before	After	Before	After
5	8,2	8,3	303	19	608	39
10	8,2	8,3	303	12	608	24
13	8,2	8,3	303	12	608	24

Internet of thing will be applied on this water treatment equipment. There are two kinds of internet of thing applied in this experiment, Bardi wireless and wireless remote control. Bardi wireless is used to control the water flow by mobile smartphone. If there is no mobile phone signal in research location and smartphone can't be used, wireless remote control is an alternative to control the water flow (see Fig. 7.a). These are installed on the water treatment equipment unit in mobile hanger which is equipped with battery and solar cell panel as its energy source (see Fig. 7.b.)

(a) (b)

Figure 7: Internet of Things technology, Bardi wireless and remote-control application and solar cell panel assembly

Sample from the treated water is sent to independent laboratory, PT Sucofindo, Surabaya, Indonesia to verify or validate the obtained experiment result. Standard water quality parameter from Minister of Health Republic of Indonesia Regulation (Peraturan Menteri Kesehatan Republik Indonesia / PERMENKES) No. 492, 2010, will be used as comparison to the experiment analysis result. The laboratory test result is shown Table 4.

Table 4: Laboratory test result, PT Sucofindo Surabaya

Parameter	Unit	Result	Max value	Method
pH ***)	-	7,21	6,5 – 8,5	9222 J #) •)
Odour	-	Odourless	Odourless	SNI 3554:2015 Item 3.2.1 **)
Colour	(Pt-Co Scale)	< 0,33	15	PO/ENV-AIR/55
TDS	mg/L	21,0	500	2540 C #)
EC	µs/cm	35,2	300	5210 B #)
Turbidity ***)	NTU	< 0,4	5	2130 B #)
Taste	-	Tasteless	Tasteless	2540 H B #)
Temperature ***)	°C	24,1	27	2550-B #)
Arsenic (As)	mg/L	< 0,0003	0,01	3114-B #)
Ammoniac (NH_3-N)	mg/L	< 0,032	1,5	4500 NH_3 F #)
Aluminium (Al)	mg/L	< 0,003	0,2	3120-B #)
Iron (Fe)	mg/L	0,007	0,3	3120-B #)
Chloride (Cl)	mg/L	6,9	250	4500 Cl^-B #)
Total hardness	mg/L	< 3,0	500	2340-C #)
Chlorine (Cl_2) ***)	mg/L	< 0,02	5	4500 Cl_2 G #)
Chromium (Cr)	mg/L	< 0,003	0,05	3120-B #)
Cadmium (Cd)	mg/L	< 0,002	0,003	3120-B #)

Mangan (Mn)	mg/L	0,012	0,4	3120-B #)
Nitrate (NO_3-N)	mg/L	< 0,15	50	4500 NO_3 B #)
Nitrite (NO_2-N)	mg/L	< 0,003	3	4500 NO_2 B #)
Selenium (Se)	mg/L	< 0,0003	0,01	3114 B #)
Fluoride (F)	mg/L	0,23	1,5	4500 F D #)
Cyanide (CN)	mg/L	< 0,03	0,07	4500 CN E #)
Sulphate (SO_4)	mg/L	0,66	250	4500 SO_4^{2-} B #)
Copper (Cu)	mg/L	< 0,003	2	3120-B #)

Conclusion

The best result from the selected local filter material is the combination of charcoal, kaolin, silica sand and sponge (Experiment no. 13). This combination can increase the pH value from 7.9 to 8.1 and decreasing the TDS value from 2450 ppm to 2360 ppm. EC value is decreasing from 4920 µs/cm to 4570 µs/cm. Physical standard quality can be achieved as odour, colour and turbidity are able to be removed with this filtration.

From the experiment with reverse osmosis equipment, it can increase the pH value about 3.75% from 8.0 to 8.3, decrease TDS value about 99,5 % from 2270 ppm to 12 ppm as well as EC value about 99.5% from 5500 µs/cm to 24 µs/cm. Hence most of the water contaminant can be removed and comply with the standard water quality parameter.

Based on both experiment result from the selected local filter material and reverse osmosis, reverse osmosis has the best result. Reverse osmosis equipment is proven to provide compliance to the water quality parameter of Minister of Health Republic of Indonesia Regulation (Peraturan Menteri Kesehatan Republik Indonesia / PERMENKES) No. 492, 2010 and WHO guidelines for drinking water. TDS and EC value from local filter material are exceeding the standard value and can't comply with the required standard quality. However, the water filtration result from filter material is suitable for the daily household usage as odour, colour and turbidity can be removed.

There are some advantages and disadvantages factor which should be considered in this research work. Combination of local filter material as an applied water treatment equipment especially in a remote area is proven as cost-effective equipment. It can help the local community to treat the water source into a better-quality standard water and suitable for household usage, not for drinking water. In term of maintenance, it is easy to maintain and clean the filter regularly. On the other side, reverse osmosis has the capability to remove almost all contaminants and useful minerals in water and provide drinking water quality. In term of maintenance, a specific instruction for maintaining semi permeable membrane must be provided and training is needed. Membrane replacement will involve huge cost for the community. Therefore, water treatment purpose should be determined at the first stage according to the daily needs in the community. Hence, a suitable water treatment equipment can be designed, which is cost efficient and simple to maintain in the future. A combination of both filtration and reverse osmosis is possible.

An application of internet of things on water treatment equipment, Bardi wireless and remote control with solar cell panel as energy source, is very helpful for the community in remote area where there is no electricity source and mobile phone signal. It can help the community to activate water treatment equipment to get the clean water.

Acknowledgement

The authors would like to convey our thanks to the community in Tegal Sari and Tanjung Sari village for their support and contribution during the research time, colleagues at Environmental Hydraulic Laboratory and lecturer at Department of Civil Engineering, Petra Christian University for their guidance. We would like to also express our appreciation for the support of the sponsors of the Directorate General of Higher Education Indonesia project number: 002/AMD-SP2H/LT-MULTI-TERAPAN/LL7/2021.

References

[1] B. I. Amalia, A. Sugiri, “Ketersediaan air bersih dan perubahan iklim: Studi krisis air di Kedungkarang, Kabupaten Demak”, *Jurnal Teknik PWK*, Vol. 3, No. 2, pp. 295-302, 2014. https://doi.org/10.14710/tpwk.2014.5058

[2] United Nations Environment Programme, "A Snapshot of the World’s Water Quality: Towards a Global Assessment", *Knowledge Repository – UNEP*, UNEP, 2016. https://wedocs.unep.org/20.500.11822/19524

[3] D.P.E. Putra, D. Halim, S.S. Widagdo, and R.R.S. Atmaja, “Degradation of groundwater quality due to the occurrence of salty-tasted water in Bayat District, Klaten, Central Java, Indonesia”, *Journal of Degraded and Mining Lands Management*, Vol. 8, No. 1, pp 2525-2536, 2020. https://doi.org/10.15243/jdmlm.2020.081.2525

[4] S. Hermawan, A. Njo, “Kegiatan program pengembangan desa mitra masyarakat pesisir desa Kupang, Kecamatan Jabon, Sidoarjo, Jawa Timur”, *Prosiding Seminar Nasional Abdimas Ma Chung*, pp. 212-221, 2020. https://ocs.machung.ac.id/index.php/senam/article/view/41/20

[5] M. Cañedo-Argüelles, B.J. Kefford, C. Piscart, N. Prat, R. B. Schäfer, C. J. Schulz, “Salinisation of rivers: an urgent ecological issue”,

Environmental Pollution, Vol. 173, pp. 157-167, 2013. https://doi.org/10.1016/j.envpol.2012.10.011

[6] C. Cooper, M. Moore, Freshwater management in wetlands and agriculture, Washington DC, Island Press, 2002. http://www.usmarc.usda.gov/SP2UserFiles/person/3938/Ch10(221-236).pdf

[7] E.R. Herbert, P. Boon, A.J. Burgin, S.C. Neubauer, R. B. Franklin, M. Ardón, K. N. Hoppensperger, L.P.M. Lamers, P. Gell, "A global perspective on wetland salinization: ecological consequences of a growing threat to freshwater wetlands", *Ecosphere*, Vol. 6, No. 10, pp. 1-43, 2015. https://doi.org/10.1890/ES14-00534.1

[8] A. L. Herczeg, S.S. Dogramaci, F.W.J. Leaney, "Origin of dissolved salts in a large, semi-arid groundwater system: Murray Basin, Australia", *Marine and Freshwater Research*, Vol. 52, No. 1, pp. 41-52, 2001. http://hdl.handle.net/102.100.100/202986?index=1

[9] V.R. Auliya, B.D. Marsono, A. Yuniarto, E. Nurhayati, "Brackish water treatment for small community by using membrane technology", *IOP Conference Series: Earth and Environmental Series*, Vol. 896, 2021. http://dx.doi.org/10.1088/1755-1315/896/1/012073

[10] A. Mugiyantoro, I. H. Rekinagara, C.D. Primaristi, J. Soesilo, "Penggunaan bahan alam zeolit, pasir silika, dan arang aktif dengan kombinasi teknik shower dalam filterisasi Fe, Mn dan Mg pada air tanah", *Proceeding Seminar Nasional Kebumian ke 10: Peran Penelitian Ilmu Kebumian dalam pembangungan infrastruktur di Indonesia*, 2017. https://repository.ugm.ac.id/id/eprint/274161

[11] S. Uliana, B. Shah, I. Raj, K. Rathore, R. Nautiyal, A. Singh, "Comparative study of different natural coagulants for the treatment of grey water with conventional alum", *Proceeding of the 2nd World Congress on Civil, Structural and Environmental Engineering (CSEE 2017)*, 2017. https://doi.org/10.11159/AWSPT17.160

[12] S.S. Marais, E.J. Ncube, T.A.M Msagati, B.B.Mamba, Thabo T.I. Nkambule, "Comparison of Natural Organic Matter Removal byUltrafiltration, Granular Activated Carbon Filtration and FullScale Conventional Water Treatment", *Journal of Environmental Chemical Engineering*, Vol. 6., No. 5, 2018. https://doi.org/10.1016/j.jece.2018.10.002

[13] R. Sasri, N. Wahyuni, K.P. Utomo, Y. Nurmaiyatri, " Filtration Treatment of Processing Kapuas River's Water by Coral Sands/Kaolinite/Activated Carbon", *AIP Conference Proceedings*, 1823, 2017. https://doi.org/10.1063/1.4978103

[14] K.C. Lai, L.Y. Lee, B. Hiew, S. Thangalazhy-Gopakumar, S. Gan, "Environmental application of three-dimensional graphene materials as adsorbents for dyes and heavy metals: Review on ice-templating

method and adsorption mechanisms", *Journal of Environmental Sciences*, Vol. 79 , pp 174 – 199, 2018. https://doi.org/10.1016/j.jes.2018.11.023
[15] S. Bano, U. Zulfiqar, S. Zaheer, M. Awais, I. Ahmad, T. Subhani, "Durable and recyclable superhydrophobic fabric and mesh for oil–water separation", *Advanced Engineering Materials*, Vol. 20, No. 1, 2017. http://dx.doi.org/10.1002/adem.201700460
[16] A.K. Maharjan, T. Kamei, K. Mori, K. Nishida, T. Toyama, "Ammonium removal from alkaline groundwater using a dropping nitrification unit with sponge or bio fringe material", *Journal of Water and Environment Technology*, Vol.19, No.6, pp 302–315, 2021. http://dx.doi.org/10.2965/jwet.21-084
[17] A.A. Nayla, A.I. Abd-Elhamid, A.A. El-Shanshoryc, H.M.A. Soliman, El-Refaie Kenawy, H.F. Aly, "Development of sponge/graphene oxide composite as eco-friendly filter to remove methylene blue from aqueous media", *Applied Surface Science*, Vol. 496, 143676, 2019. https://doi.org/10.1016/j.apsusc.2019.143676
[18] I. F. Nucifera, T. A. Zaharah, I. Syahbanu, "Uji stabilitas kitosan-kaolin sebagai adsorben logam berat Cu (II) dalam air ", *Jurnal Kedokteran dan Kesehatan*, Vol. 5, No. 2, pp. 43-49, 2016. https://jurnal.untan.ac.id/index.php/jkkmipa/article/view/14896/13113
[19] D. Apriadi, D. Jubaedah, M. Wijayanti, "Pengaruh frekuensi pembilasan filter arang aktif batok kelapa dan spons pada sistem resirkulasi terhadap kualitas air media pemeliharaan ikan maanvis (pterophyllum scalare)", *Jurnal Akuakultur Rawa Indonesia*, Vol. 5, No. 2, pp. 120-129, 2017. https://docplayer.info/138305325-Pengaruh-frekuensi-pembilasan-filter-arang-aktif-batok.html
[20] Z. Ikhwan, "Efektivitas penggunaan arang batok kelapa sebagai media penyaring penurunan kadar besi dan mangan pada penjernihan air kolam penambangan batu bauksit", *Jurnal Kesehatan*, Vol.5, No. 2, pp. 150-153, 2016. https://ejurnal.poltekkes-tjk.ac.id/index.php/JK/article/download/48/42
[21] F.Y. Purwaningtyas, Z. Mustakim, M.T. Umaminingrum, M.A. Ghofar, "Pengaruh ukuran zeolit teraktivasi terhadap salinitas air payau di desa kemudi dengan metode adsorpsi", *Prosiding Seminar Nasional Teknik Kimia "Kejuangan"*, Yogyakarta, Indonesia, 2020, http://jurnal.upnyk.ac.id/index.php/kejuangan/article/download/3604/2724
[22] D.S. Ayou, H.M. Ega, A. Coronas, "A feasibility study of a small-scale photovoltaic-powered reverse osmosis desalination plant for potable water and salt production in Madura Island: A techno-economic evaluation", *Thermal Science and Engineering Process*, Vol. 35, 101450, 2022. https://doi.org/10.1016/j.tsep.2022.101450

[23] S.H. Saiful, N.K. Rahmi, "Cellulose acetate from palm oil bunch waste for forward osmosis membrane in desalination of brackish water", *Results in Engineering*, Vol. 15, 100611, 2022. https://doi.org/10.1016/j.rineng.2022.100611

[24] Honarparvar S., Zhang X., Chen T., Alborzi A., Afroz K., Reible D., "Frontiers of Membrane Desalination processes for Brackish Water Treatment: A Review", *Membranes*, Vol. 11, No. 246, pp. 1-52, 2021. http://dx.doi.org/10.3390/membranes11040246

[25] A.A. Chairunissa, D. Prasetyo, E. Mulyadi, "Pembuatan air demineral menggunakan membran reverse osmosis (RO) dengan pengaruh debit dan tekanan", *Jurnal Teknik Kimia*, Vol. 15, No. 2, pp. 66-72, 2021. https://doi.org/10.33005/jurnal_tekkim.v15i2.2544

[26] M. K. Akbar, Desain Marka Terminal Apron Bandar Udara Haji Muhammad Sidik, Kota Muara Teweh, Kalimantan Tengah, 2020. http://eprints.itenas.ac.id/id/eprint/1199

[27] A. Junaidi, "Internet of things, sejarah, teknologi dan penerapannya: Review", *Jurnal Ilmiah Teknologi Informasi Terapan*, Vol. 1, No. 3, pp. 62-66, 2015. https://doi.org/10.33197/jitter.vol1.iss3.2015.66

[28] D. Susanto, T.U. Kalsum, Y.Suzantri, "Alat penyaring air kotor menjadi air bersih menggunakan mikrokontroller atmega 32", *Jurnal Media Infotama*, Vol. 10, No. 2, pp. 142-150, 2014. https://doi.org/10.37676/jmi.v10i2.244

[29] Kementerian Kesehatan Republik Indonesia, *Permenkes No. 492 tahun 2010*, Kementrian Sekretariat Negara Repulik Indonesia, Jakarta, Indonesia, 2010.

[30] World Health Organization, *Guidelines for drinking-water quality,* 4th ed. World Health Organization: Geneva, Switzerland, pp. 3-493, 2011.

[31] P.A. Scherman, W.J. Muller, C.G. Palmer, "Links between ecotoxicology, biomonitoring and water chemistry in the integration of water quality into environmental flow assessments", *River Research and Applications*, Vol. 19, No. 5-6, pp. 483-493, 2003. http://dx.doi.org/10.1002/rra.751

[32] A.F. Rusydi, "Correlation between conductivity and total dissolved solid in various type of water: A review", *IOP Conf. Series: Earth and Environmental Science*, 118, 2018. http://dx.doi.org/10.1088/1755-1315/118/1/012019

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