Penerbit Akademia Baru

Journal of Advanced Research in Fluid Mechanics and Thermal Sciences
ISSN (online): 2289-7879 | Vol. 9, No. 1. Pages 19-27, 2015

Natural Groundwater Eco-Treatment (N-GET) for Water Supply at Johor, Malaysia

S. Musa[*,a], *F. Denan*[b], *R. Hamdan*[c] *and R. M. S. Radin Mohamed*[d]

Faculty of Civil and Environmental Engineering, Universiti Tun Hussien Onn Malaysia
86400 Batu Pahat, Johor, Malaysia
[*,a]*sabariah@uthm.edu.my*, [b]*eina_virgurl90@yahoo.com*, [c]*rafidahh@uthm.edu.my*, [d]*maya@uthm.edu.my*

Abstract – *Groundwater is an alternative source to supply water to consumers. The groundwater well is available at RECESS which is situated in UTHM campus containing low quality of groundwater. This research was conducted to identify the effectiveness of the Nature Groundwater Eco-Treatment (N-GET) system that has been designed at RECESS for daily usage. N-GET system is a natural treatment process without mixing any substances intended to improve the quality of groundwater can give benefits especially to users at RECESS. N-GET system uses four tanks in the treatment of groundwater which are aeration tanks, sedimentation tanks, suction tanks and distribution tanks. Seven parameters was tested which is pH, turbidity, dissolve oxygen (DO), manganese, sulphate, chloride and nitrate with 15 numbers of sample. The water quality (pH value, turbidity, dissolve oxygen (DO), manganese, sulphate, chloride and nitrate) was improved and this system 100% effectively to treat the contaminant of groundwater. After the treatment by using this system, the water was pass the water quality standard which produced by Ministry of Health Malaysia (KKM). Thus, this system was implemented that the usage of water from various sources with simple, easy, practical treatment and low cost of construction. Therefore, this system will trigger idea of producing groundwater treatment by applying the natural concept as well as for the best purpose and more environmental friendly in the future.*

Keywords: Groundwater, Water Quality, Nature Groundwater Eco-Treatment (N-GET)

1.0 INTRODUCTION

Nowadays, four districts in Johor which are Kluang, Mersing, Kulaijaya and Kota Tinggi are experiencing water shortage that could lead to schedule water rationing [1]. Due to this crisis, groundwater is a suitable option to supply water for consumers. With the availability of this alternative, it can help users to get their water supply. As a first step to solve this problem, there are several groundwater wells that have been constructed in Research Centre for Soft Soil Malaysia (RECESS). Batu Pahat district is an area of soft clay and organic matter content in the soil affecting the groundwater parameters. Among the parameters contained in the groundwater is high sulphate and chloride [2]. There are also other parameters such as manganese and nitrate. Besides that, a state of clay containing limestone can affect the pH of the groundwater [3]. However, an easy and systematic method of treatment can be used to ensure that the water that has been supplied is safe and clean to be used by consumers.

The study of groundwater treatment is conducted at the campus of Universiti Tun Hussein Onn Malaysia (UTHM) that located the system at RECESS. A treatment system known as Nature Groundwater Eco-Treatment (N-GET) has been built in the area RECESS for treatment of groundwater. This treatment process gone through four tanks which are aeration tanks, sedimentation tanks, suction tanks and distribution tanks which are used naturally in treating groundwater. This system also has one filter between the sedimentation tank and suction tanks. This treatment is a nature treatment without mixing any chemical or substance to react to groundwater.

This study focused on water quality performance of the N-GET system was designed for daily use in RECESS, UTHM. Groundwater samples were pumped into the N-GET (control samples at the first tank) and samples of water that flows through each tank was compared to determine the effectiveness of the treatment system designed. Parameters for all samples tested were pH, dissolved oxygen (DO), turbidity, manganese, chloride, nitrate and sulphate. Water samples were passed through N-GET system compared with drinking water quality standard issued by the Ministry of Health (KKM) [4].

1.1 Related Studies

Groundwater is suitable for drinking as the contaminant content found in groundwater is smaller than surface water [5]. However, the study area contents of chloride, sulphate, nitrate and manganese are parameters that interfere with the quality of underground water [1,7]. Air Kelantan Sdn. Bhd. (AKSB) is the only drinking water treatment company that uses groundwater as a source of raw water [6]. Basically, AKSB is using a treatment process that consists of 5 levels of ventilation, condensation and coagulation, sedimentation, filtration, chlorination and pH correction. As the water that have been used is channelled domestically, there are chemicals that been added in every treatment process such as alum and polymer solution. Many studies have been conducted to ensure the quality of underground water meets the standards issued by World Health Organization (WHO) and the United Stated Environment Protection Agency (USEPA) and the Ministry of Health (KKM).

There are several methods of treatment for groundwater that have been conducted to ensure that water supplied beyond and meet the required standards. Among them are the treatment methods of sustainable bio-absorption, mixing rainwater treatment methods, and methods of ceramic treatment. Organic matter can improve water quality by reducing some of the parameters pH, chloride, sulphate, nitrate and manganese. However, all value obtained are not passing the drinking water standards issued by the Ministry of Health [1]. In addition, with the use of absorption of roses from species Rosa Centifolio, the manganese content is reduced, while increasing the percentage of nitrate content. However, the treated water exceeded water quality standards issued by the NDWQS [7]. Method of absorption of seeds of tree species Maringa Oleifera as gathering mechanism in the water showed that the pH, turbidity and the chloride can be reduced. All values obtained exceeded the drinking water quality standards issued by the WHO [8].

Dilution method with the addition of rainwater will add and improve water quality. However, groundwater quality is still not surpassed standards of water supply for consumers directly [9].By using a sand filter that undergone two parts of treatment which is the treatment of sedimentation and filtration treatment found that the water quality can be improved by increasing the pH and the removal percentage of manganese, iron and chloride [10]. A few stages of water filter containing media such as activated carbon, silica sand and rock mineral

Penerbit Akademia Baru
Journal of Advanced Research in Fluid Mechanics and Thermal Sciences
ISSN (online): 2289-7879 | Vol. 9, No. 1. Pages 19-27, 2015

used in layers found that the effectiveness of the system is between 78-100%. Among the parameters that can be eliminated is the chloride, nitrate and sulphate as well as the increment in the pH [11]. Besides that, the method of treatment that uses filtration and ventilation find that water quality can be improved. Ventilation methods are used as an additional treatment method for supplying oxygen in the water. The experimental results showed that the pH, turbidity, manganese, and iron DO can be reduced. Water that has been through this process can meet drinking water standards produced by Ministry of Health (KKM) [12].

Based on previous studies, it was found that the methods used have not been able to remove 100% of groundwater parameters. Through this study conducted by N-GET system, the system are more effective in improving water quality and eliminate contaminants found in groundwater with the use of natural treatment without mixing chemicals.

2.0 METHODS

N-GET system was shown in Figure 1 has four treatment tanks were aeration, sedimentation, suction and distribution tanks. Besides that, the system was equipped with a aerated filter that was located between the treatment and the suction tanks. This system applies a natural concept to make sure the contaminant of groundwater removed by using a easy and simple treatment without any chemical dosage.

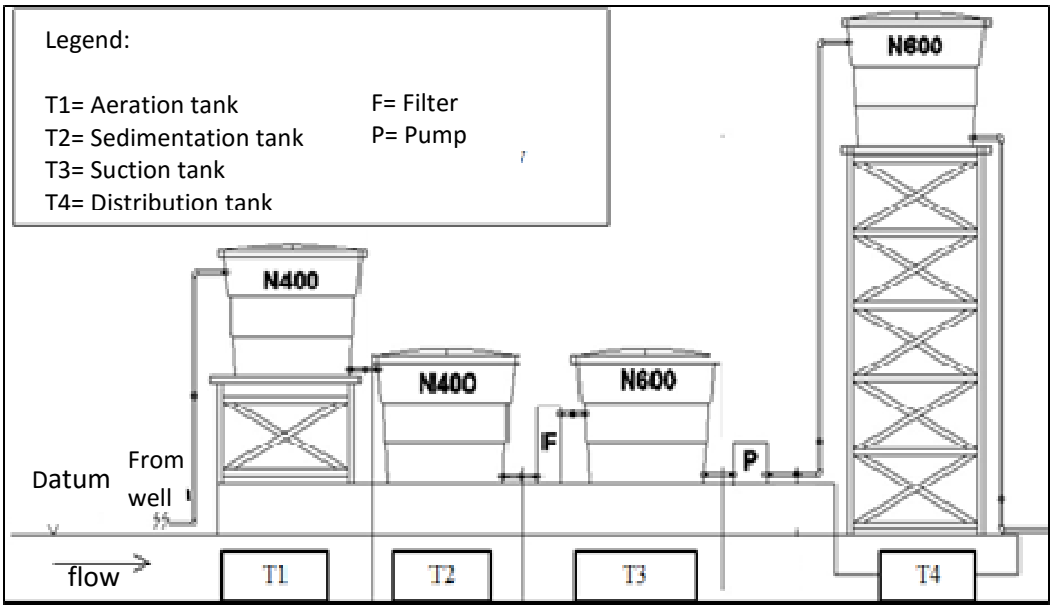


Figure 1: Nature Groundwater Eco-Treatment (N-GET) system

N-GET system starts from the aeration tank was contains of water capacity of 400 gallons. The water is pumped into the aeration tank for the purpose of increasing the amount of dissolved oxygen in the water, add fresh taste to the water and reduce the smell of hydrogen sulphide in the water. N-GET system uses ventilated diffusion method. Diffusion aeration was done in the tank for 24 hours. The air was absorbed through the porous pipe supplied with compressed air and oxygen dissolved in the water when compressed air is released through the porous pipe. After the aeration tank, the water was flowed into the sedimentation tank with 400 gallon water capacity. Sedimentation process does not use any elements to the

deposition such as alum or a polymer solution. Water into the tank was be left within a time period of 24 hours to deposit material impurities and clear water that water flows from the top. Water that has sediment was flows through a filter that traps fine particles and bacteria. Screening is important to get rid of materials that could not be cleaned during the deposition process. Medium from river rock 50mm-60mm sized was applied to filter and maintain the natural elements without any interference or any element that can cause water pollution. The treated water was collected and stored in the suction water tank for the distribution purpose. Suction tank containing 600 gallon of water capacity load. Water in the suction tank is clean and clear. From the suction tank, water was pumped through the pipeline system to offset the reservoir with sufficient height for distribution using the gravity concept. This distribution tank was load 600 gallon water capacity.

2.1 Sampling and Testing

The purpose of sampling, samples water that pumped into the first tank was used as control sample and water out of each tank contained in the N-GET system taken as samples tank. There are 15 samples with three sets of experiments. By making measurements of water before treatment (control sample) and samples after treatment (sample each tank), the effectiveness of the N-GET was analyzed by comparing at the results of the parameters pH, dissolved oxygen (DO), turbidity, manganese, chloride, sulphate and nitrate for every stage.

All water samples were taken and tested in the laboratory according to the parameters of water quality. This experiment aims to identify whether the quality of the water that undergo N-GET system in each tank meets the quality standards that have been set. The analyses were performed to determine the number of parameters such as pH and dissolved oxygen (DO) using Water Quality Checker tool HORIBA model. Hach 2100N Turbiditimeter was used to measure the turbidity. The Hach DR6000 spectrometer instrument was used to measure the manganese. To measure the parameters of chloride, sulphate and nitrate, the test using ionizing tool-Chromatography (IC) was conducted. These tests were taken approximately 4-6 weeks and each experiment.

3.0 RESULTS AND DISCUSSION

The results of each experiment on the underground water parameters before treatment N-GET (control sample) and after treatment with N-GET (aeration, sedimentation, suction, and distribution tanks) shown in diagrammatic form.

3.1 Laboratory Phase

Figure 2 shows the results of the pH value and turbidity. The pH value before treated in the N-GET was 7.81 while after N-GET system was 7.22. It showed that 8% was decrease in pH and N-GET system succeeded in raising the pH to a more neutral and beyond the limits of the KKM standards of 6.6-9.0. Based on the results, all tank in the system N-GET have potential in treating pH value. The treatment stage in the aeration tank and a sedimentation tank took about 24 hours for each tank has caused water to be closer to neutral.

Penerbit Akademia Baru
Journal of Advanced Research in Fluid Mechanics and Thermal Sciences
ISSN (online): 2289-7879 | Vol. 9, No. 1. Pages 19-27, 2015

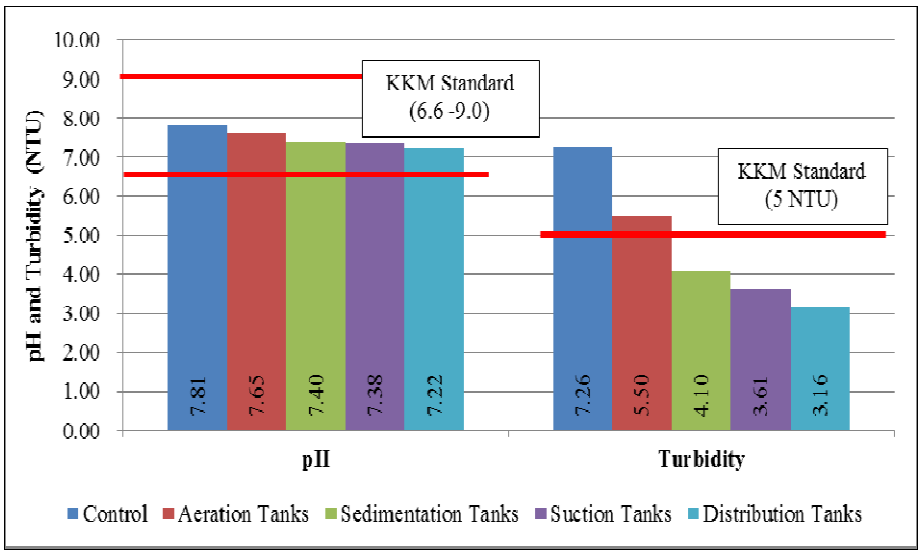


Figure 2: pH and turbidity's results

The turbidity parameter values obtained before undergoing N-GET system was 7.26 NTU. Turbidity value has dropped to 3.16 NTU with the removal of 56%. At the level of ventilation were 5.5 NTU turbidity values and standards which have not exceeded standards which is 5 NTU. Therefore, sedimentation and filtration processes essential to reduce turbidity. Through this process, it can help to accelerate the removal of turbidity to ensure the water is free of odour and unpleasant taste.

Figure 3 was shows the results of dissolved oxygen (DO) and nitrate. Dissolved oxygen (DO) increased by 44% from 6.70 mg/ L to 9.65 mg/L when going through the N-GET system. In the early stages of treatment in the aeration tank the DO has not succeeded to increase to the desired level of 7.50 mg/L. In the sedimentation tank, suction tank and tank distribution, all value have been exceeded standards on behalf of the KKM. Although this increase is not increased by 100%, the value obtained has reached the KKM standards of 8.0-10.0 mg/L. Dissolved oxygen values can be used as indicators of water pollution degrees because the lower the dissolved oxygen content, more contaminated the water will be.

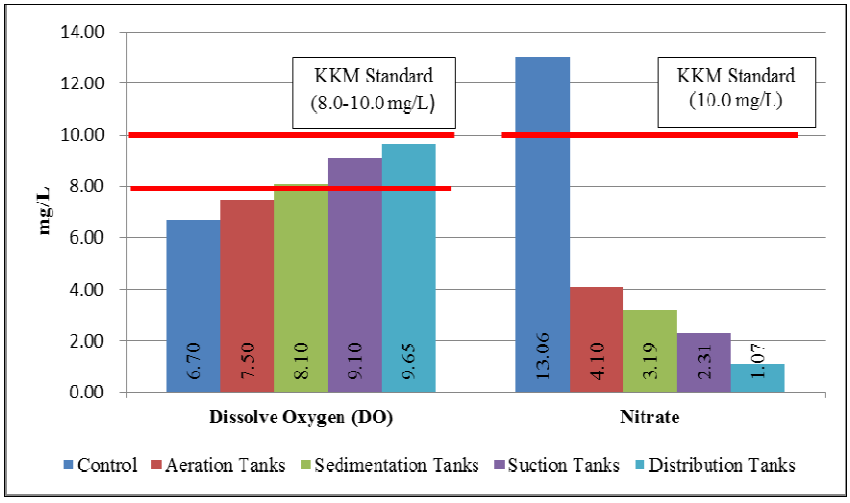


Figure 3: Dissolve oxygen and nitrate's results

Penerbit Akademia Baru

Journal of Advanced Research in Fluid Mechanics and Thermal Sciences
ISSN (online): 2289-7879 | Vol. 9, No. 1. Pages 19-27, 2015

Nitrate content also can be eliminated up to 92% when undergoing treatment with N-GET system. Nitrate content after the treatment process was reduced from 6.13 mg/L to 1.07 mg/L. It showed nitrate can be eliminated by 11.99 mg/L of untreated water samples. Results of the analysis found that all four tanks in the N-GET system capable to get rid of nitrate exceeded the drinking water quality standards by Ministry of Health (KKM) of 10.0 mg/L for nitrate content. From the early stages of treatment showed N-GET system has managed to get rid of nitrate content exceeded drinking water standards set by the KKM. Data obtained showed that only 8% of the amount of nitrate that was left after treatment with N-GET system.

KKM set the standard for chloride and sulphate content was 250 mg/L. Figure 4 shows the experimental results for both parameters. Parameter heavy chloride in groundwater showed the highest reading 1518.49 mg /L before undergoing treatment. 4 based treatment tanks in the system N-GET, only successful distribution tank sulphate content decreased to 249.38 mg/L with the removal of 84%. However, the value obtained surpassed the limit KKM standards in the supply of drinking water of 250 mg/L. This suggests that although chloride is a difficult parameter to be treated, however N-GET systems can produce water that meets quality standards.

From the control samples 1389.46 mg/L, the content of sulphate removed by 70% in the aeration tank of 417.09 mg/L. Increase in the sedimentation tank removal of 82% of 251.73 mg/L. Improved in removal was closer to KKM standards had caused by particles that decomposed in the aeration tank deposited in sedimentation tanks. Deposition time of 24 hours also helps the removal of sulphate. On the suction tank sulphate content is declining to 152.31 mg/L and continued to decrease in the distribution tank of 115.80 mg/L with removal rates of 92% and surpassed the standard of 250 mg/L.

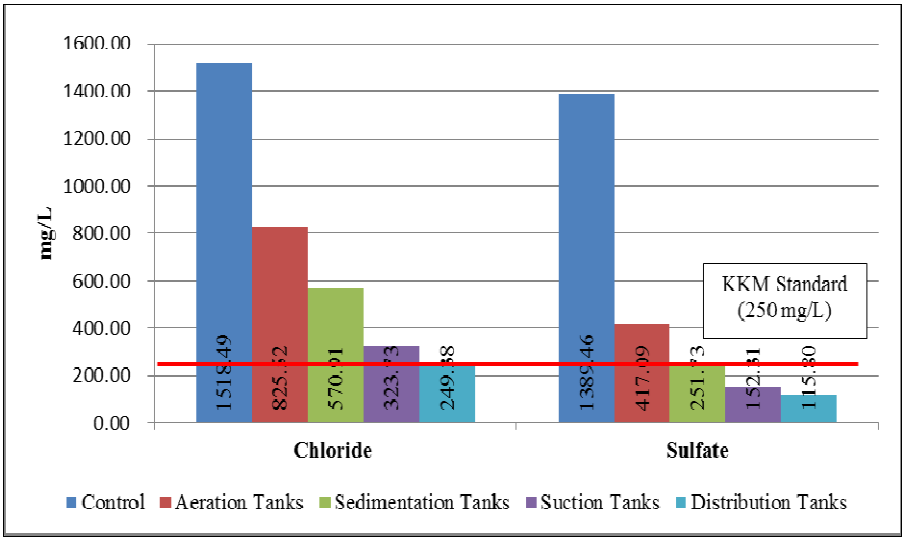


Figure 4: Chloride and sulfate's results

Besides the manganese content can be eliminated as much as 100% when going through the N-GET system. High manganese content value of 1.20 mg/L decreased to reading 0.00 mg/L, as shown in Figure 5. The results of the analysis in the early stages of treatment in the N-GET system that involves aeration and sedimentation tanks showed the manganese content 0.70 mg/L and 12.31 mg/L. The result was obtained showed that water on this stage yet reached

Penerbit Akademia Baru

Journal of Advanced Research in Fluid Mechanics and Thermal Sciences
ISSN (online): 2289-7879 | Vol. 9, No. 1. Pages 19-27, 2015

the limits of the drinking water quality standards KKM of 0.1 mg/L. Filtering medium that was used for trapping fine particles cause the water entered the suction tank was free from manganese content. This indicates that the manganese content can be eliminated using simple filtering medium.

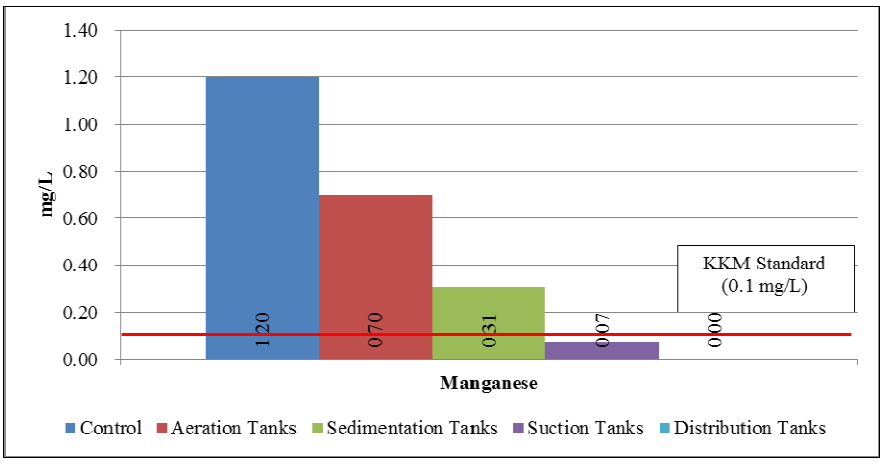


Figure 5: Reduction of manganese result

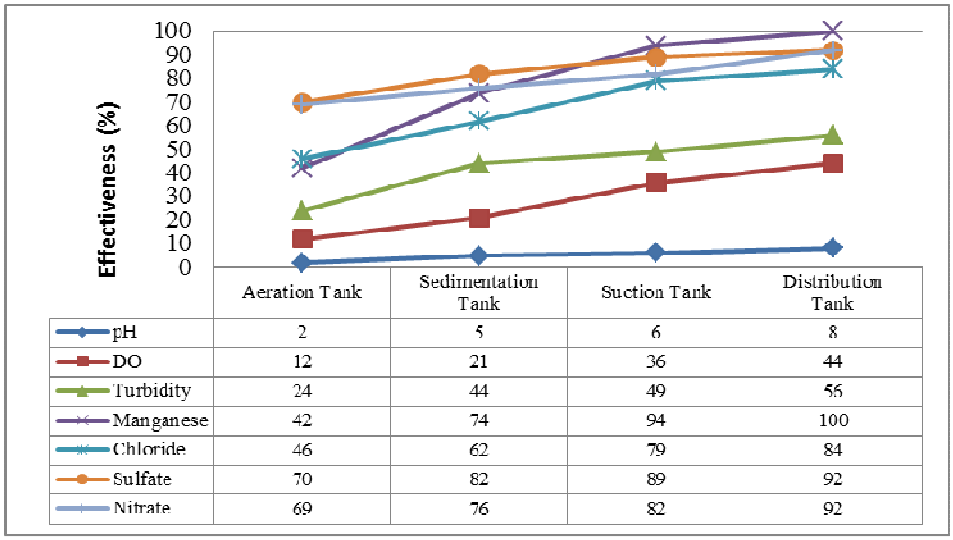
3.2 Effectiveness of N-GET System

Table 1 shows the overall results of the effectiveness of N-GET system while Figure 6 shows effectiveness of the treatment for every treatment tank in the N-GET system. The results from laboratory test that has been conducted found that all parameter meet the standards issued by the Ministry of Health (KKM). Although in the early stages of the treatment process the parameters are not removed, but after successfully gone through N-GET system, the entire parameters can be treated to surpass the standards. The changes of quality for each parameter were shown in Table 1 and Figure 6.

Table 1: Parameters Quality change

Parameter	Before Treatment (Control Sample)	After treatment (N-GET System)	KKM Standard	Effectiveness (%)	Remarks
pH	7.81	7.22	6.6- 9.0	8% Decreased	Fulfill KKM standard
Dissolve Oxygen (DO), (mg/L)	6.70	9.65	8.0-10.0	44 % Increased	Fulfill KKM standard
Turbidity (NTU)	7.26	3.16	5.0	56 % Removed	Fulfill KKM standard
Manganese (mg/L)	1.2	0.00	0.1	100 % Removed	Fulfill KKM standard
Chloride (mg/L)	1518.49	249.38	250	84 % Removed	Fulfill KKM standard
Sulfate (mg/L)	1389.46	115.80	250	92 % Removed	Fulfill KKM standard
Nitrate (mg/L)	13.06	1.07	10	92 % Removed	Fulfill KKM standard
N-GET System effectiveness				100 %	

Penerbit Akademia Baru
Journal of Advanced Research in Fluid Mechanics and Thermal Sciences
ISSN (online): 2289-7879 | Vol. 9, No. 1. Pages 19-27, 2015



	Aeration Tank	Sedimentation Tank	Suction Tank	Distribution Tank
pH	2	5	6	8
DO	12	21	36	44
Turbidity	24	44	49	56
Manganese	42	74	94	100
Chloride	46	62	79	84
Sulfate	70	82	89	92
Nitrate	69	76	82	92

Figure 6: The N-GET system effectiveness

Based on analyzed phase, the highest removal is manganese which was 100%. While the content of sulphate and nitrate showed great potential in the elimination of over 90%. Chloride also eliminated more than 80% and these analyses shows great potential in improving the removal such as manganese, sulphate and nitrate. Dissolved oxygen was upgraded to a better level. The pH value is not decreasing that much but it remains in a stable condition. Overall, the system shows that the N-GET system 100% effective based on the standards of the KKM. All parameters tested successfully passed the prescribed limit. This shows positive results in improving the quality of underground water.

4.0 CONCLUSSION

Through the studies conducted, N-GET system was effectively in treating and improving the quality of groundwater with stabilized of pH value and increasing the dissolved oxygen content. Turbidity values were also reduced by this treatment system. In addition, through this treatment system parameters can be eliminated such as manganese, nitrate, chloride and sulphate, and consequently improving the quality of groundwater in the area of RECESS, UTHM. The water quality was undergone this N-GET system has passed the quality standards of drinking water supply by the Ministry of Health (KKM) and at the same time past the raw water supply standards. Therefore, underground water which has been treated may be used for internal and external use in RECESS, UTHM. This study indicates that positive towards the treatment process and water treatment and drinking water supplies as simple as a natural treatment system without mixing chemicals in each tank in the N-GET system. Local population or community can apply this system for commercial and domestic purposes more natural and environmental friendly.

ACKNOWLEDGEMENT

Great thanks to Malaysian Ministry of Education for Exploratory Research Grant Scheme (Vot. E039), Universiti Tun Hussein Onn Malaysia and special thanks go to RECESS for kindly providing us location for this project.

REFERENCES

[1] Suruhanjaya Perkhidmatan Air Negara (SPAN), Krisis Bekalan Air, August 2014.

[2] S. Musa, N.A. Zakaria, T.Z. Lau, R.M.S. Radin Mohamed, M.I. Amir, M. Ibrahim, A. Adnan, Kaedah Lestari Bio-Serapan dalam Merawat Air Bumi Menggunakan Bahan Organik, Proceedings of Seminar Kebangsaan Aplikasi Sains dan Matematik (2013) 41-49.

[3] J. Samshuddin, M. Anda, Charge properties of soils in malaysia dominated by kaolinite, Gibbsite and Hematite, Geology Society of Malaysia Bulletin 54 (2008) 27-31.

[4] Kementerian Kesihatan Malaysia, Piawaian Kebangsaan Kualiti Air Minuman Mentah (Piawaian Air Bawah Tanah), Malaysia, 2000.

[5] A. Endut, Kajian Kualiti Air Perigi Persendirian di Mukim Manir Kuala Terengganu, Final Year Project thesis, Universiti Teknologi Malaysia, 2006.

[6] Air Kelantan Sdn. Bhd. (AKSB), 2014

[7] A. Abd Kadir, N. Othman, N.A.M. Azmi, Potential of using Rosa Centifolio to remove iron and manganese in groundwater treatment, International Journal of Sustainable Construction Engineering & Terminology 3 (2012) 70–81.

[8] S.M. Mangale, G. Chonde Sonal, P.D. Raut, Use of moringa oleifera (drumstick) seed as natural absorbent and an antimicrobial agent for ground water treatment, Reseach Journal of Recent Sciences 1 (2012) 31-40.

[9] M.F. Mohd Yusuf, Study on the Quality of Groundwater Recharge Well As Alternative Source for Water Supply in the Field Laboratory of RECESS, Final Year Project, Universiti Tun Hussein Onn Malaysia, 2009.

[10] T.Z. Tengku Ahmad, The Study Of The Effectiveness Of Various Water Filler Treatment Unit, Final Year Project, Universiti Tun Hussein Onn Malaysi, 2009.

[11] C.A. Peng, Meningkatkan Kualiti Air Di Kuittho: Penggunaan Sistem Penapis Air Berperingkat, Final Year Project, Universiti Tun Hussein Onn Malaysia: Projek Sarjana Muda Kejuruteraaan Awam, Tesis, 2005.

[12] N.N. Nik Daud, N.H. Izehar, B. Yusuf, A. Thamer, M.A. Ahsan, Groundwater Quality Improvement by Using Aeration and Filtration Methods, Proceedings of World Academy of Science, Engineering and Technology 7 (2013) 403-407.