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Removal of Physical Properties in Water Supply by WASRA for Sustainable Irrigation System

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ABSTRACT

Background: In irrigation, water is essential to assist in the growing of agricultural crops, maintenance of landscapes, and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall. Most importantly, water quality can be a limiting factor in plant growth. Thus, this study was performed to analyze and compare between raw and treated water by WASRA system in terms of water quality effectiveness. This research also determines the potential groundwater resources for irrigation purposes at University Malaysia Pahang (UMP) nursery based on Interim National Water Quality Standard for Malaysia (INWQS). WASRA system manages to effectively remove 100% suspended solid followed by turbidity 93.59% and colour 89.54%. From the result, it can be concluded that treated groundwater using WASRA system can be used for irrigation purpose at UMP nursery as it can improve the water quality parameter.

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INTRODUCTION

Agriculture uses approximately 70% of the world's freshwater supply [1]. Agricultural water use is under growing pressure as demands for water increases across the globe. Competition among agriculture, industry and cities for limited water supplies is already constraining development efforts in many countries. As populations expand and economies grow, the competition for limited supplies will intensify and so will conflicts among water users. Despite water shortages, misuse of water is widespread. Small communities and large cities, farmers and industries, developing countries and industrialized economies are all mismanaging water resources [2-4]. Surface water quality is deteriorating in key basins from urban and industrial wastes.

There are many types of water resources on earth. The common water resource is from the water surface for instance stream, pond, river or freshwater wetland. These surface water resources basically function for the agricultural use, for industrial use and for the generation of different types of energy such as hydro electrical energy. Another type of water resource comes from groundwater. Groundwater can be made either by capillary flow from the phreatic surface or from an aquifers. The groundwater withdraws through tube wells when there are groundwater irrigation is considered. Generally, the purpose of groundwater is to irrigate fields that surround the pump and known as a localized gravity. Consequently, comprehensive statistics for irrigation on use of groundwater are not available [5]. Thus, UMP researchers has created water supply system in the rural area (WASRA) that produce high quality water and provide a reliable and economical alternative source for irrigation purpose. This system has the ability to removes impurities from water by means of a fine physical barrier, a chemical process or a biological process.

Investigation Area:

Water samples were collected from Universiti Malaysia Pahang (UMP) nursery located at Gambang, Pahang. This nursery nurtures a diverse collection of ornamental plants for the university landscape design purpose and sprinkle irrigation was applied to irrigate all the plants in this area. The untreated water samples were taken from raw water tank inside the water system while treated water was taken from the water that flows through the sprinkler.

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Fig. 1: UMP Nursery.

WASRA System:

WASRA system is the new system that designed mainly to supply clean water for rural area. This system function is to treat the groundwater and rainwater harvesting to pass through the pre treatment process by using ultra filtration membrane and raw material before distributed to rural communities.

Water Sampling Procedure:

Samples were manually collected before and after treatment using two bottles. Treated samples were collected from the sprinkler after it was operated after 5 minutes. After collection, the sample bottles were labeled and brought to the laboratory after 10 minutes of collection. The label stated the time of collection, date and sampling point of the sample taken. All samples were tested at the Environmental Laboratory in Faculty of Civil Engineering Universiti Malaysia Pahang.

Sample Collection:

For this study, water sample were collected, tested and recorded 30 times in 6 month duration. Consistency and accuracy of data depends on the sampling frequency. The physical and weather conditions on the sampling day were also recorded to ensure any condition that may affect the result. The samples collected were tested at laboratory on the same day. To prove the significance of all data, SPSS statistical program was used to calculate all the statistical analysis (ANOVA).

Laboratory Experiments:

Four physical parameters for water quality testing such as total suspended solid, turbidity, pH and colour were tested at the Environmental Laboratory in Faculty of Civil Engineering, Universiti Malaysia Pahang. Water samples were collected and tested 30 times in duration for 4 month starting from December 2014 until April 2014. All the data recorded were compared with the Interim National Water Quality Standard (INWQS).

RESULTS AND DISCUSSIONS

Suspended Solid:

Total suspended solids (TSS) is not considered as a major threat in water but the increase of TSS may make the water body to lose its ability to support the diversity of aquatic life. Based on Figure 2, the highest suspended solid value measured from untreated groundwater is 30 mg/L while the lowest is 0 mg/L taken from treated groundwater by WASRA. This results shows that suspended solid value for both raw and treated groundwater were within the acceptable value for INWQS. According to INWQS, the maximum level allowed for suspended solid is 300 mg/L for irrigation purpose and suspended solid below 25 mg/L is considered as Class I. Fig 2 shows that suspended solid of treated groundwater by WASRA is in standard level of Class I which can be conclude that the water is clear and good in condition. Although both untreated and treated groundwater had allows for irrigation, it proves that WASRA system was able to remove 100% suspended solid thus increased the quality of water supply.

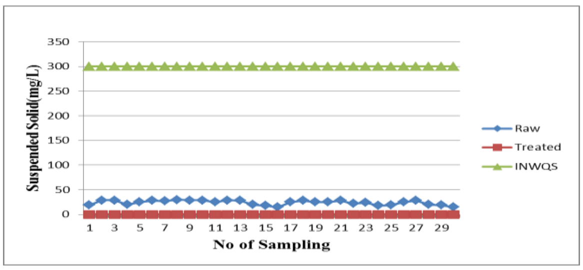

Fig. 2: Suspended solid of raw and treated groundwater

Table 1 shows the result for suspended solid test using ANOVA. The significance of the parameter was based on the p-value. The Interim National Water Quality Standard (INWQS) recorded the highest mean rather than raw and treated groundwater. According to the statistical table, the P value for this test is 5.1 x 10-150 which is lower than the critical P value which is 0.05. This result shows that null hypothesis for these 3 groups are rejected and there is a significant differences of the value between the raw groundwater, treated groundwater and also Interim National Water Quality Standard (INWQS)

Table 1: Summary of One-Way ANOVA for suspended solid

Source of Variation	MS	P-value	F-critical
Between Groups	833676	5.1E-150	3.1012
Within Groups	7.0915		
Total	833683		

Turbidity:

Turbidity is the one of the most important indicator for water clarity to be carried out in this experimental programme. Turbidity measurement indicates that the highest value is measured in raw groundwater with 16.88 NTU while the lowest value of turbidity is 0.61 NTU in treated groundwater. Since obtained turbidity for treated groundwater is below 5 NTU thus it can be classified as Class I. In irrigation, the value accepted for turbidity is 0 NTU according to INWQS which shows that groundwater need to be treated by WASRA system to qualify the requirement. The results indicate that treated groundwater is comparable with the acceptable values of INWQS for irrigation.

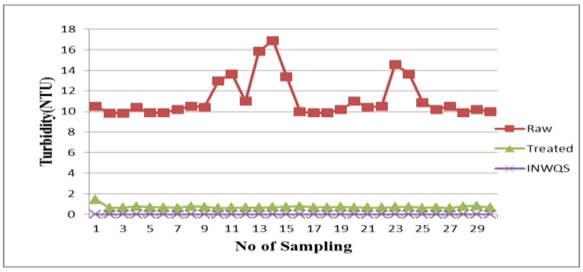

Fig. 3: Turbidity of untreated and treated groundwater.

Table 2 shows the result of turbidity test using ANOVA. Based on the results, the Interim National Water Quality Standard (INWQS) recorded the highest mean compared to raw and treated groundwater. The P value recorded for this test is 1.2 x 10-59 which is lower than that of the critical P value 0.05. Thus, we can reject the null hypothesis for these 3 groups at 95% confidence level. There is a difference in reading value between the raw groundwater, treated groundwater and also Interim National Water Quality Standard (INWQS).

Table 2: Summary of One-Way ANOVA for turbidity.

Source of Variation	MS	P-value	F-critical
Between Groups	1185.2	1.2E-59	3.1012
Within Groups	1.2601		
Total	1186.4		

Colour:

As most domestic and industrial usually prefer colourless water, this experimental programme was conducted to compare between untreated and untreated groundwater as in Figure 4. It can be seen that there are huge gap of value between raw and treated groundwater that is 105 TCU for raw water and 5 TCU for treated groundwater by WASRA. INWQS requires 0 TCU for irrigation requirement and raw groundwater colour failed to meet the requirement while treated groundwater value are closer to the acceptable range for the purpose. Nevertheless, WASRA had significantly improve the groundwater quality from Class IIA to Class I.

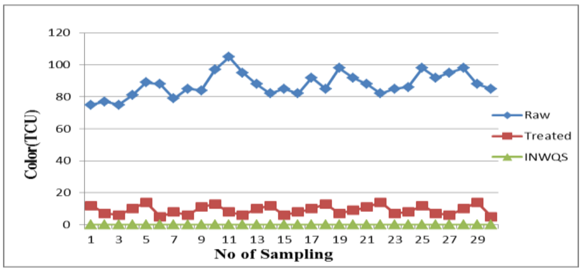

Fig. 4: Colour of raw and treated groundwater.

Table 3 shows that the result of colour parameter by applying ANOVA in which the significance of the parameter was based on the p-value. As expected, the highest mean value was recorded for Interim National Water Quality Standard (INWQS) compared to raw and treated groundwater. From the statistical table shown below, the P value for this test is 5.93 x 10-83 which is lower than the critical P value 0.05. This showed that, we can reject the null hypothesis for these 3 groups. So, there is a difference of reading between the raw groundwater, treated groundwater and also Interim National Water Quality Standard (INWQS).

Table 3: Summary of One-Way ANOVA for colour.

Source of Variation	MS	P-value	F-critical
Between Groups	69714	5.93E-83	3.101
Within Groups	20.901		
Total	69734		

pH:

Comparison of untreated and treated groundwater is shown in Figure 5. From the figure, there is slightly improvement in pH value when groundwater was treated by WASRA system that is from 7.01 to 6.24. The acceptable pH range for irrigation usage is between 5 to 9 and both raw and treated groundwater samples are within this range.

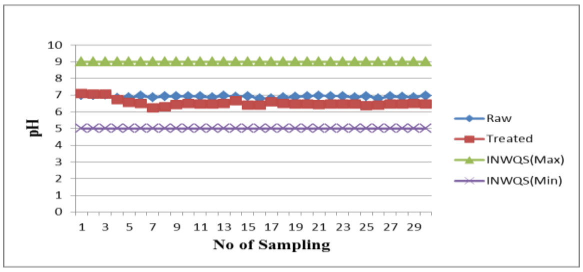

Fig. 5: pH value of untreated and treated water samples.

The pH result by using ANOVA is presented in Table 4. From the table shows that there is a significant difference in terms of value between treated water and Interim National Water Quality Standard (INWQS) with 95% confidence level limit as the critical value is 0.05 which is higher than the P-value which is 9.8 x 10-132. Therefore, the null hypothesis can be rejected.

Table 4: Summary of One-Way ANOVA for Ph.

Source of Variation	MS	P-value	F-critical
Between Groups	81.512	9.8E-132	2.6828
Within Groups	0.0112		
Total	81.523		

Interim National Water Quality Index (INWQS):

The Interim National Water Quality Standards classifies water quality in six classes (I, IIA, IIB, II, IV and V) and water quality has been adopted as the primary basis for the classification of water uses. Table 5 and 6 below shows the summary results of untreated and treated groundwater by WASRA. All the samples tested were based on four physical parameters that are suspended solid, turbidity, color, and pH. All the samples have been tested at Environmental Laboratory Universiti Malaysia Pahang (UMP) and the results was recorded.

Table 5: Average value of raw groundwater with INWQS classification

Water Parameter	Average Raw Groundwater	INWQS
Suspended Solid	24.03	Class I
Turbidity	11.23	Class 11A
Color	87.7	Class IIA
pH	6.91	Class I

Table 6: Average value of treated groundwater with INWQS classification.

Water Parameter	Average Treated Groundwater	INWQS
Suspended Solid	0	Class I
Turbidity	0.72	Class I
Color	9.16	Class I
pH	6.53	Class I

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Table 7: Percentage Removal Before and After Treated

Water Parameter	Average Reading Before Treatment	Average Reading After Treatment	Percentage Removal (%)
Suspended Solid	24.03	0	100
Turbidity	11.23	0.72	93.59
Colour	87.70	9.17	89.54

In water quality classification, water quality parameters were compared to INWQS and the results shows that the parameters for total suspended solid, turbidity, colour and pH in raw groundwater is not in acceptable range to be used for irrigation purpose as the suitable class for irrigation purpose used is in CLASS IV. On the other hand, treated groundwater by WASRA increased water quality significantly as all the parameter were classified in Class I according to the Interim National Water Quality Standard (INWQS). Based on this result, it showed that the treated groundwater is clean and safe from any contaminant and can be used for irrigation purpose.

Conclusions:

Summary of the study was made based on the result of analysis of water quality class in support with ANOVA hypothesis test. The result from this study would provide useful information on groundwater quality in Universiti Malaysia Pahang. The result also proved that treated groundwater using WASRA system improves the water quality parameter to CLASS I and shows that it is suitable to be used for irrigation purpose.

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