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# Performance of Rambutan Seed Extracts as Iron and Manganese Removal in Drinking Groundwater well in Tanah Merah, Kelantan

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## Abstract

Groundwater is a major source of drinking water supply espeacially in Kelantan due to shortage of clean surface water. However, groundwater quality is found to be high in hardness, salinity, and concentration of iron, manganese, ammonium and flouride especially at rural area in Kelantan. Therefore, groundwater should be treated before it can be used for domestic purposes. Currently, water treatment used chamicals for heavy metals removal although chemicals were known to be hazardous for human consumption. Thus, plant based material was proposed to give more environmental friendly approach for drinking water treatment especially groundwater. The objective of this study is to determine the performance of extracted rambutan seed in removal of iron (Fe) and manganese (Mn) from groundwater. Groundwater sample were collected from seleced wells in Tanah Merah district, Kelantan, Malaysia. Iron and manganese contents of groundwater samples were measured before and after the jar test in the laboratory by using Atomic Absorption Spectrophotometer (AAS). All water samples were tested with different concentration of rambutan seed cruded extracts. The experiments were carried out with coagulant dosage of 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0 mg/L with the interval of 1.0 mg/L. The results show that, *Nephelium lappaceum* seed can remove up to 91.38% of Fe in groundwater sample by using optimal dosage of l/L. The seed also able to remove up to 90.91% Mn in groundwater samples using the optimal dosage 5mg/L. The high removal rate for both iron and manganese reflected that rambutan seed has a potential to replace chemicals coagulant in water treatment. Hopefully with this finding, peopl will have access to reasonable price, clean and safe drinking water and the goverment can also save a few thousand ringgit for treatment expenses.



## 1. Introduction

Water is one of the essentials that support all forms of plant and animal life (Vanloon & Duffy, 2005). In many rural areas and small communities, groundwater serves as the only source of drinking water. In fact, more than 50% of world population depend on groundwater for domestic use (Marcovecchio et al., 2007). In Kelantan itself, about 70% of the total drinking water supply is derived from groundwater (Mohamad Azwan et al., 2010) but the increasing industrialization process in developing countries as well as the rapid population growth and the vast agricultural activities have contributed to increment of pollution in natural environment such as soils, water or air (Morrison et al.,1990; Vodela et al., 1997). The heavy metal contents in groundwater have signifcantly increased especially ferum and manganese due to pollution caused by anthropogenic activities (Idris et al., 2014). Heavy metals are defined as elements which have atomic weights between 63.546 and 200.590 and a specific gravity greater than 4.0, at least 5 times that of water. Their exist in water in colloidal, particulate and dissolved phases (Adepoju-Bello et al., 2009). High concentrations of Fe and Mn in groundwater can result in discoloured water, skinned plumbing fixtures and an upleasant metallic taste to the water (Brian et al., 2001). The Government of Malaysia via Ministry of Health has come out with "National Standard for Drinking Water Quality for Malaysia" where the concentration for ferum and manganese in raw water the limited to 1.0 mg/L and 0.2 mg/L respectively. Meanwhile for treated water the limits are 0.3mg/L for ferum and 0.1mg/L for manganese. Therefore, groundwater treatment which is widely used among water providers especially in Kelantan utilized alum as coagulant to remove all the pollutants including heavy metals although alum is expensive and known to be hazardous to human and also environment. Therefore, agricultural wastes that are available in large quantities may have potential to be used as low cost coagulant because they represent unused resources that are widely available and environmental friendly.



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Rambutan seed was selected as coagulant to remove iron and manganese in ground water, due to high seed oil content and Vitamin C which is believed to have high absorbent properties. At the same time, rambutan seed is agricultural waste which can be found abundant especially during fruit season, therefore, the price is much lower as compared to chemicals. Rambutan (*Nepheliumlappaceum L.*) is a tropical fruit belongs to the Sapindaceae family. The fruits are ovoid, with a red or yellow pericarp covered with soft spines that vary in colouring from green, yellow and red. They possess an edible aril (rich in vitamin C) that is white or translucent, sweet and juicy and clings to the testa seed (Nakasone & Paull, 1998; Smith et al., 1992; Wall, 2006). Malaysia's main rambutan-growing areas are Kelantan, Johor, Terengganu, Pahang and Kedah that covered 26,946 hectare and able to produce 86,085 metric tons of fruits in 2011. The present study focuses on the extraction of rambutan seed to be used as coagulant and to determine the effectiveness of using rambutan seed extracts (coagulant) to remove ferum and manganese in ground water treatment via Jar Test. Rambutan fruit was bought from a local wet market to get the seed. The objective of this study is to determine the effectiveness of rambutan seed coagulant in removing ferum and manganese in ground water as well as to determine the optimum dosage of coagulant. This study will contribute to the knowledge required to resolve environmental problems as well as health impacts in drinking water treatment.

## 2. Materials and Methods

### 2.1. Groundwater Sample Collection

A total of 8 wells from different villages in Tanah Merah, Kelantan, Malaysia were randomly selected as sampling stations for groundwater (Figure 1). The well selected for sampling was used for domestic purposes, especially drinking and cooking by the folks. Ground water samples were collected for two consecutive months which are March and April in 2013. A total of 1L groundwater was filtered on site for each sampling point and later preserved using 50% $HNO_3$ before it was stored under 4°C inside cooler box. These water samples were brought back to the laboratory for sample analysis. Concentration of Mn and Fe at various locations were determined using Atomic Absorption Spectrophotometer (AAS) before and after the jar test.

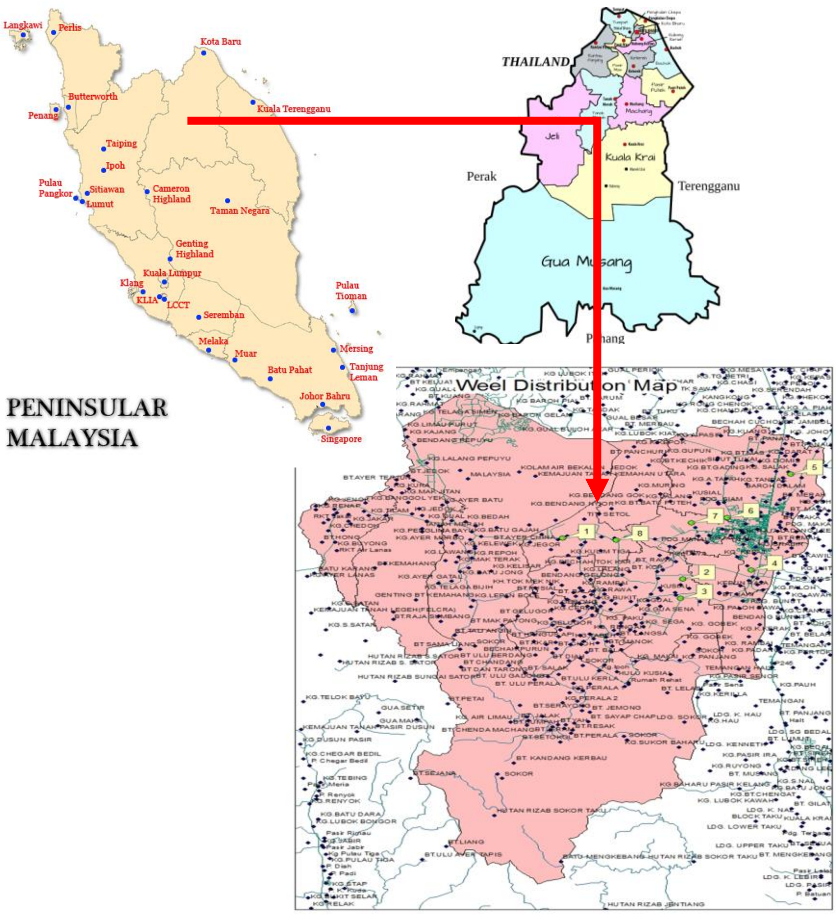


**Figure 1:** Groundwater sampling stations in Tanah Merah, Kelantan (Source: Google Map)



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### 2.2. Rambutan Extraction Preparation

On the other hand, rambutan fruit was bought from fruit stalls in Tanah Merah area to get its seed. The flesh and skin of rambutan fruit was removed from the seed and then, the seed was cut into smaller pieces and dried for two days with the temperature of 50°C in the oven before ground. Later, grounded seed powder was sieved through 0.4mm and the particles smaller than 0.4 mm were used for extraction. Rambutan seed crude extract was prepared by adding 0.1g rambutan seed to 100ml distilled water. The mixture was then stirred using magnetic stirrer for 60 minutes before left for settled down and filtered through 0.95mm paper filter.

### 2.3. Groundwater Sample Treatment Test

Jar-test was performed in 8 cleaned BOD bottles, each bottle was added with 100mL groundwater sample and top-up with difference concentrations of rambutan seed extract. Dosage of rambutan seed crude extracts were used in increasing volume from 1mL, 2mL, 3mL, 4mL, 5mL, 6mL, 7mL, and 8mL. The standard procedure implies 3 minutes of rapid mixing (200rpm) in the incubator shaker at 21°C temperature followed by 30 minutes of slow mixing (50rpm) for flocculation. The treated water was allowed to settle for 20 minutes and 50mL of the sample was taken from the top of each BOD bottle to measure and analyse the concentration of Fe and Mn. The process was repeated by replacing raw groundwater with distilled water as a blank. The difference concentration of Fe, and Mn before and after treatment was used to indicate the effectiveness of rambutan seed in reducing these parameters in groundwater. On the other hand, heavy metals removal was presented in the form of percentage by using the formulae below:

$$Biosorbent\ removal\ (\%) = Ci - Ca \times 100$$

Where,
Ci – Initial concentration of Iron and Manganese (mg/L)
Ca – Concentration of Iron and Manganese after treatment (mg/L)

After jar test, the remaining flocculant was separated from the solution by filtering through a Whatman (0.45 µm GF/C) filter paper and the filtrate was analysed using AAS to determine Fe and Mn ions concentration.

## 3. Results and Discussion

### 3.1. Physico-chemical Characteristics of Groundwater

Table 1 shows the overall values of the concentration of Fe and Mn collected from 8 wells in Tanah Merah area. Ground water number 1 allocated in Kg. Jegor, number 2 in Kg. Kusial, number 3 in Kg. Gual, number 4 in Kg. Kebun Rasa, number 5 in Kg. Salak, number 6 in Tanah Merah, number 7 in Kg. Manal and number 8 in Kg. Kulai Tiga. There were two sets of data because sampling was done for two months, March and April of 2013. The values obtained were compared with the benchmark set in the "National Standard for Drinking Water Quality" published by the Ministry of Health Malaysia

**Tab1e 1**: Comparison of water quality with National Standard for Drinking Water Quality and WHO Standard

| Parameter | Month | Station | | | | | | | | Maximum Acceptable Value (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| Manganese (mg/L) | March | 0.006 | 0.06 | 0.011 | 0.049 | 0.192 | 0.045 | 0.069 | 0.073 | 0.1 |
| | April | 0.017 | 0.07 | 0.051 | 0.131 | 0.174 | 0.147 | 0.192 | 0.218 | |
| Iron (mg/L) | March | 0.046 | 0.115 | 0.058 | 0.132 | 0.064 | 0.087 | 0.823 | 0.07 | 0.3 |
| | April | 0.07 | 0.067 | 0.054 | 0.076 | 0.072 | 0.128 | 0.448 | 0.089 | |

Generally, the Mn concentration has increased from March to April 2013 but the concentration was not significant ($p>0.5$). On the other hand, when compared with the "National Standard for Drinking Water Quality" published by the Ministry of Health Malaysia and WHO standard, concentration of Mn at station 4, 5, 6, 7 and 8 in April 2013 exceeded 0.1 mg/L. Meanwhile, Fe concentration did not vary much from March to April 2013 where the different was also not significant ($p>0.5$). However, concentration at station number 7 exceeded 0.3 mg/L (MOH, 2004; WHO, 1996) for both months. It could be concluded that, drinking water for the folks in Tanah Merah District contained high Mn and Fe at certain well, especially well number 4 to 8 but well number 1 to 3 were safe for consumption. Basically, the value of Mn and Fe recorded is in-line with finding from Mohd Idris and Wan Rohaila (2014) where they reported, the mean concentrations of Mn and Fe in untreated drinking ground water well in rural area of Kelantan are 0.76 mg/l ± 1.37 and 0.27 mg/l ± 0.12 respectively.

### 3.2. Iron and Manganese Removal

The Ferum and Manganese concentration decreases after the first dosage (1 mg/L) of rambutan seed extract being added to the water sample. The concentration of Ferum and Manganese keep on decreasing until dosage 6 mg/L and 5 mg/L respectively



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where after that the concentration increased to certain level before remained constant. Based on the results, optimum dosage for maximum removal was 6 mg/L for Ferum and 5 mg/L for Manganese with the removal rate up to 91.38% and 90.91% respectively. The performance of rambutan seed in Ferum removal was slightly lower as compared to removal by Rosa Centifolia (99.55%). However, the removal of Manganese was slightly higher as compared to removal by Rosa Centifolia (89.93%) (Aeslina *et al*., 2012).

## 4. Conclusion

In conclusion it could be suggested that, rambutan seed extracts have very high performance in removing iron and manganese in ground water and have the potential to be used as coagulant in water treatment.

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