Study on the efficiency of removing some environmental pollutants in yellow water by using sand and brick powder

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Abstract: *Urine and flush water is known as yellow water in general. Releasing of untreated urine to the environment causes bad odor, aquatic and terrestrial pollution also. The main focus of this research is to investigate the usage of sand and red brick powder to remove environmental pollutants in yellow water. Filtration column used for the study was packed by using sand or brick particles in the range of 0.270-0.355 mm diameter. Continuous flow filtration through column of sand or brick powder was investigated for removal of total nitrogen, color, conductivity and COD caused by urine. Whilst brick powder demonstrates good filtration efficiency, sand is found to be inefficient for the intention. Initial efficiencies demonstrated by brick powder for removal of total nitrogen, color, conductivity and COD were 93%, 92%, 55%, 65% respectively and decreased upon continuous filtration except for total nitrogen. During the study, total nitrogen removal efficiency remained constant.*

Keywords: *Yellow water, Urine, Brick, Sand, Total nitrogen, COD*

1. INTRODUTION

Urine and flush water, known as yellow water, is the nutrient richest component of domestic waste water output whilst gray water and brown water also contribute on nutrient content of domestic waste water. Waste water form kitchen and bath is known as gray water. Brown water may contain feces, toilet papers and flush water (UN 2006). Since one liter of urine averagely contains 14 g of nitrogen, 0.8 g of phosphorous and1.7 g of potassium (Putnam 1971), yellow water remains the nutrients richest even after being diluted with flush water. There are many environmental problems related with urine. Average urea content of urine is 16.3 g/L^{-1} and hydrolysis of urea in urine gives an unpleasant odor (Udeart *et al.* 2003). Although urine is expelled from the body as a sterile liquid, urine provides necessary nutrients and good environment for microorganism growth (Medes and Lynch 1976). Therefore, many pathogenic microorganisms can be proliferated on urine. It has been reported that large number of hydrophilic pharmaceuticals residuals are excreted with human urine. Often they are excreted only with slightly or no transformation (Heberer 2002). Synthetic estrogen compounds, the active ingredients of contraceptives, has been found in human urine at higher concentrations (Pacakova 2009). Although the environmental concentrations of estrogens are very low, their adverse effect on the reproduction of wildlife and humans is significant. Berkowitz (1941) has reported that, inhibition of development of secondary sex characteristics of male fish upon exposure to estrogen. Also such treated fish, took on female appearance regardless of their gender. This clearly indicates that, allowing urine to reaching aquatic bodies may have adverse effects on fish and other aquatic organisms. Also these pharmaceutical residuals may undergo different chemical reactions upon chlorination, which is used for disinfection of drinking water in Sri Lanka. Mixing yellow water and other domestic waste water and releasing to aquatic bodies is one of major reasons of their eutrophication (Tidakar 2003). A large number of researches have been carried out to investigate the use of urine as nutrient rich liquid fertilizer. Pradhan *et al.* (2007) has reported that human urine can successfully substitute for industrial chemical fertilizers. National Aeronautics and Space Administration (NASA) reports, recovering potable water by reverse osmosis of pretreated urine.

Currently in Sri Lanka, urine is allowed to mix up with household waste water and sent to septic tanks. Although illegal, in some cases combined household waste water is released to the environment without any treatment. Especially, in the case of mobile toilets which are mostly used at outdoor special occasions, untreated urine is released in to the municipal waste water even without dilution. In such incident, a large volume of urine is released to the environment within a short period causing bad odor and rapid pathogen proliferation. The main focus of this research is to investigate the usage of sand and red brick powder to remove environmental pollutants in yellow water.

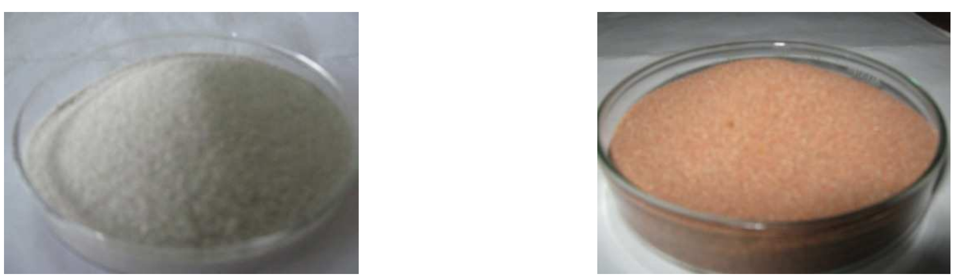
Kahn and Zareen (2006) have reported successful usage of granite sand for removal of anionic surfactants in water. Selvaraju and Pushpavanam (2009) has reported successful usage of fired red brick powder to remove chlorides, nitrates and phosphates in gray water. Also brick powder has shown good adsorption properties than sand having same particle sizes, due to its high surface area and increased wettability. Priyantha *et al.* (2011) has reported that the brick particle surfaces are negatively charged and having better adsorption properties of positively charged heavy metal ions. Carbon particle are formed in brick due to partially burnt organic matters at firing and they adsorbs both negatively charged and neutral species. Therefore, it is important to investigate red brick powder for pollutant removal of yellow water.

2. METHODOLOGY

Chemicals were obtained from Merck, Fluka, BDH, S.D. Fine-Chem Ltd. and Himedia. Analytical grade reagents were used whenever it was possible. pH measurements were carried out by Cyberscan 510 pH meter. Color was measured using DR/890 Data logging Colorimeter. TDS of samples were measured by Cpberscan PC 300 TDS meter.

2.1. Material preparation

Sand was collected from different areas of the country. Sand particles in between 0.270-0.355 mm in diameter was separated after sieving, washed with tap water, mud and dirt were removed, washed again with distilled water and allowed to dry at 80^0 C (Figure 1a).
Red brick were collected form Galle area and crushed by mortar and pestle. Brick particles in different size ranges separated after sieving, washed with distilled water until colorless washings and allowed to dry at 80^o C (Figure 1 b).



(a) (b)

Figure 1 (a) sand and (b) brick powder after preparation process

2.2. Filtration column preparation and use

Filtration columns were prepared with sand and or brick powder separately. An amount of 290g of sand or brick powder was used to pack a column with 3 cm diameter and 50cm bed height. Urine samples were collected from university students and working staff and samples were mixed. Urine filled to the column, allowed to flow through the column continuously and the flow rate was maintained at 50ml/hr.
The column effluent was collected and removed for analysis after each hour.

2.3. Chemical analysis

Chemical analysis of column effluent was carried according to ASTM waste water analysis procedures. COD was measured by closed reflux method. Total Nitrogen was analyzed by kjeldhal method.

3. RESULTS AND DISCUSSION

3.1. Efficiency of pollutant removal by sand

Removal efficiency (E) of all parameters (X) was calculated by;

$$E = \left(\frac{X_{Influent} - X_{Effluent}}{X_{Influent}} \right) \times 100\%$$

Color removal efficiency of different types of sand in the range of 0.270-0.355 mm in diameter is exploited in figure 3.1.

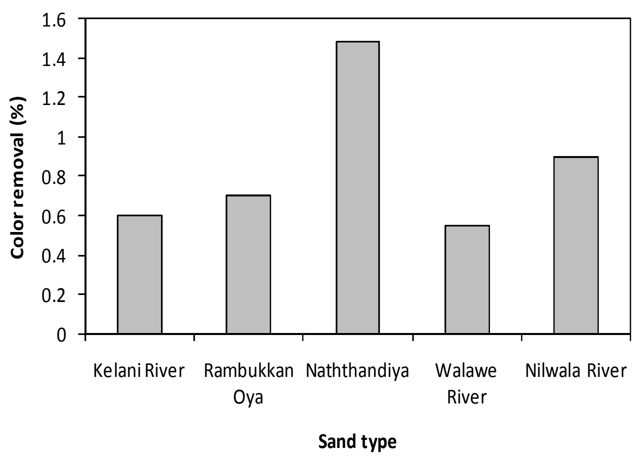


Figure 2 Efficiency of color removal by different types of sands

As exploited in figure 2 any type of sand is not efficient for removing color of urine. Color of urine is due to urobilin, which is a conjugated organic bio molecule (Lepp, 2006). COD and total kjeldhal nitrogen analysis revealed filtration through sands are having negligible effect on those parameters, confirming poor adsorption properties of sand. Although sand is reported to be efficient in raw water treatment (Fuhrman *et al,.2005)*, they are not effective for removing highly concentrated pollutants in urine. Out of five sand types Naththandiya sand, which are having fresh surfaces showed the best adsorption properties. Active surfaces of sand types collected from river beds may be already saturated with mud and other pollutants and may lead to poor adsorption properties.

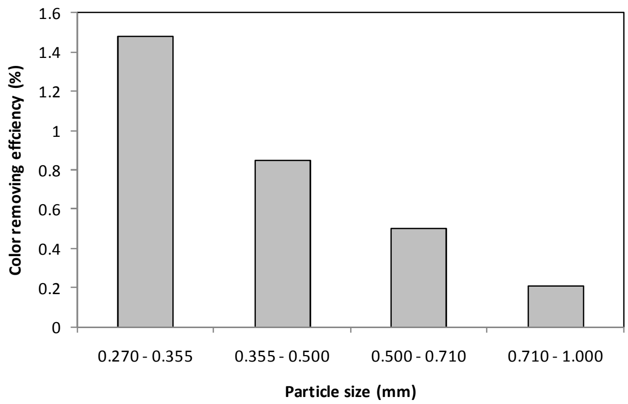
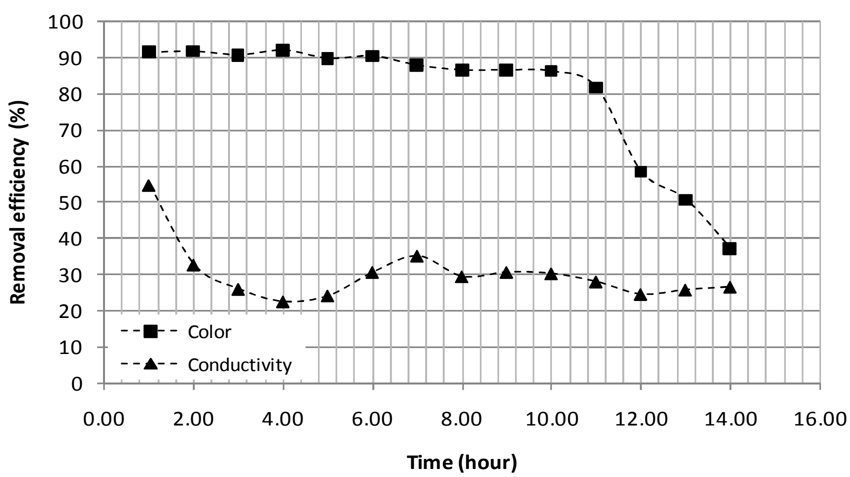


Figure 3 Color removal efficiency of Naththanadiya sand

Color removal efficiency of different particle sized of Naththandiya sand is shown in figure 3. It was observed that smaller sand particles which have higher surface area are more efficient in color removal. Sand particles are smaller than 0.270 were not suitable to be used as a filter material, because of making colloids in the solution and results in slow filtration process. Therefore optimum particle size was selected as 0.270-0.355 mm. Since all types of sand were not sufficient enough for pollutant removal in urine, red brick particles in the range of 0.270-0.355 mm were investigated to be used for the purpose.

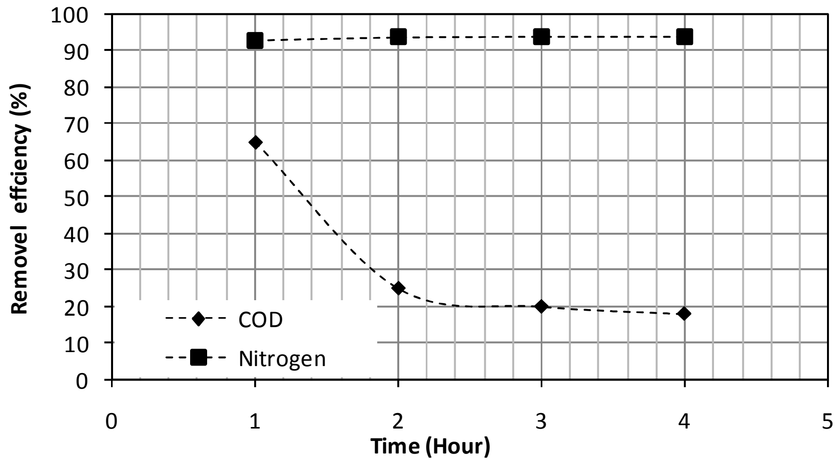
3.2. Efficiency of pollutant removal by red brick powder

Efficiencies of color and conductivity removing efficiencies posed by brick powder is exploited in figure 4 Conductivity reducing efficiency was gradually decreased with the time indicating the breakthrough of dissolved solids after 4 hours. Color removing remained at higher efficiency 10 hours and thereafter showed a sharp decrease may be due to formation of saturated monolayer.



(a)

Figure 4 (a) Color and conductivity (b) COD and total nitrogen removing efficiency by brick powder



(b)

Figure 4 Continued

COD and total nitrogen removing efficiencies by brick powder are shown in figure 4 (b). Chemical analysis was limited to four effluent samples collected through consecutive 4 hours, due to time constrains. Analysis were carried out in triplicate and averaged. Throughout the time brick powder has shown good ability to decrease the total nitrogen content of yellow water. COD of urine is reported to be a very high value (~8,000 mg/dm^3) and may cause to severe environmental stress (Putnam 1971). COD reducing efficiency also showed a sharp decrease after one hour indicating a formation of monolayer carbonaceous matter. Also the effluents were free of odor.

Brick powder can be used for mobile urinals to prevent the bad odor caused by yellow water. Since brick powder has a higher efficiency to retain nitrogenous compounds, exhausted filter materials can be used as a nitrogen rich fertilizer. Already urine is used a nitrogen rich liquid fertilizer. But, handling of liquids may be cumbersome than a solid.

For this research urine was used without any dilution, while yellow water contains few times diluted urine. Removal efficiencies will be higher for diluted urine than the reported efficiencies for undiluted urine.

4. CONCLUSIONS

Collected sand types are not efficient to remove the pollutants in yellow water. Brick powder has shown a good color and total nitrogen removing ability. Although brick powder has ability to decrease the COD and the conductivity of yellow water, the breakthrough is quick. Brick powder is suitable to be used a filter material in mobile urinals.

5. ACKNOWLEDGEMENT

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