Natural water purification system for local community

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SUSTAINABLE DEVELOPMENT OF WATER RESOURCES, WATER SUPPLY AND ENVIRONMENTAL SANITATION

Natural water purification system for local community


Introduction
Provide adequate amounts of quality for human consumption is a basic need for ensuring the sustainable, long-term supply of such drinking water is of national and international concern.

Groundwater represents an important source of drinking water; however its quality is currently threatened by a combination of factors such as over-abstraction, chemical and microbiological contamination etc. The quality of groundwater in some parts of the country, particularly shallow ground water, is reputed to be changed as a result of human activities. Ground water is less susceptible to bacterial pollution compared to surface water, as the soil and rocks through which ground water flows screen out most of the bacteria. Never the less on their way into ground water, bacteria may exist in high concentrations along with dissolved mineral and organic constituents.

Chemical pre-treatment, coagulation, sedimentation, membrane filtration and ultra violet disinfections are some options available to produce good quality drinkable fresh water.

Methods like reverse osmosis are the available technology to produce good quality water. These systems are costly to maintain. Such systems are unapprovable for the small communities of the 3rd world countries. As such, in order to supply quality water for the communities with high population density, law cost, simple water purification methods to the small hold level.

The present paper, to introduce a simple natural water purification system at which can make drinking water at home hold level to produce good quality fresh water.

Study area
The research site is located in the Faculty of Agriculture University of Ruhuna, Mapalana, Kamburupitiya Sri Lanka. Open shallow dug well was selected to obtain the ground-water for purification within the Faculty premises. Dug well is constructed using cement with apron and well opening is protected using a wire mesh. Dug well is constructed in an unconfined aquifer consists sandy clay and laterite.

Method and procedure
Water samples were analyzed to identify the chemically and bacteriological influence of each treatment step. Water samples were collected before and after treatment at the every step and water quality analyzes conducted respect to Electrical conductivity (EC), Total dissolved solids and salinity was measured using portable EC/pH meter. The water samples were collected at point 1, 2, 3 and 4, which randomly in (figure 1) the time period from May to September 2005.


Main storage tank
The tank is 300 l volume, black colored with a lid to minimize algae growth. Even though availability of raw water fluctuates, the main storage tank has ability to provide continuous water supply.

Sedimentation tank
Main purpose of this step is sedimentation of the suspended and colloidal materials by gravity. It needs enough stability time to settle down the particles. The time taken of the sediments depends on quality of raw water, which may carry particles of different size.
During sedimentation process, most the colloidal particles settle at the bottom strata of the water column.

**Aeration tank**

Outlet of the second sedimentation tank opens to three glass tanks, which contain Eichhornia crassipes, Salvinia molesta (water hysinth) and Anhydrilla verticillata plant with number of small fish. Water comes from second sedimentation tank passes through these three glass tanks (Biological purification unit) sequentially. Outlet of the biological purification unit opens to filtration unit. The filter is a 300 l plastic tank placed with several layers of fine sand and coconut charcoal in alternatively. The aeration process releases odor-forming gasses such as Methane, Hydrogen sulfide. Because of the availability of Oxygen of the stage some chemicals are oxidized (Ferric hydroxide) and tend to be precipitated. Aeration helps to eliminate to anaerobic microorganisms.

Plants absorb most of the ions especially nitrogenous compounds. In The aeration tank, fish and plants helps to increase the quality of water by reducing, excess of nutrients (Nitratates, Phosphates) etc.

In this micro ecosystem by fish, helps to regulate excessive plant growth.

**Filtration tank**

This also a 300l plastic tank, filled with river sand and active carbon in separate layers. Active carbon has an ability to adsorb suspended colloidal particles from the solution. Charcoal normally decreases the concentration of Non-polar substances (substances which are non soluble in water) organic elements. Active carbon make internal adsorbent surface (between 500 - 1500 m2/g) adsorbed the halogenated substances such as I-, Br-, Cl-, H+ and F-. (http://www.lenntech.com/feedback2.htm)

According to the Rachwal, A.J., biological filtration is occurred in slow sand filters. Chemical coagulants, algae, clay are filtered in respective level. (Rachwal, 1997).

**UV radiation for water disinfections**

The filtrate that comes from filter goes to drinking water tank after through a UV treatment. UV lamps have been shell with shine metals to prevent UV leakage to the out side. There are two UV lamps at the UV treatment unit and one UV lamp is at the drinking water tank.

**Drinking water tank**

This is the last component in the purification system. It is sufficient enough to meet daily consumption of 5-member family according to the Sri Lankan consumption pattern.

In order to areas the impact of each component of the system on the quality of water samples were collected before and after treatment at the every step. The water samples were collected randomly at the point 1, 2, 3 and 4, (Figure 1) May to September 2005.

**Results and discussion**

The quality of raw water in respect to Fe+2/+3, Mg+2, Na+1, K+1, Ca+2, NH4+, NO2-, NO3-, SO4-2, Coli form, E coli prior to the treatment by the water purification is given in the Table 2.

According to the results of the above system water quality parameters, source water is suitable for drinking purposes in respect to mineral contents. How ever water is positive for coli form and E coli. The coli form bacterial level of the raw water was 153.4 MPN. E coli contamination was 1.8MPN.

**A. Effectiveness of step vise treatments on electrical conductivity and total dissolved solids**

Effectiveness of the sedimentation, bio treatment, filtration and UV treatment on EC and TDS are given in the Figure 2. Results revealed that the EC of water has not changed due to the different treatments. Flow rate of the water through the system was 3.77L/min. there was hardly any time to absorb ions which dissolved in water by the plants. Therefore TDS is not changed due to the above treatments.

**B. Effectiveness of step vise treatments on pH and turbidity**

Changes of pH level of water at different stages of the treatment are given in the Figure 3. There is a significant increment of pH at the bio treatment unit (in aeration tank).

It is evident that pH is significantly increase when water passes though the bio treatment unit. The reasons for the pH increment may be the reduction of NO3-1 level at the sedimentation level onwards. Due to the excretion of am-
monia forms by the fish. During sedimentation step, turbidity level reduced by 26.51%. (Figure 3) But in Aeration tank is increased up to 1.06 NTU. Residues of aqua plants and feces of fish may be the reason for turbidity increment. However from raw water to drinking water tank, turbidity reduction is 47.76% and remained as 0.58 NTU.

The ammonia may be dissolved in water directly and produce Ammonium hydroxide. It causes to rise up of pH level in water. Further research is needed to make a firm conclusion on this regard.

On the other hand acid forming gasses such as H2S, CO2 and Cl2 may release in this step. When also may a causative factor to raise the pH level. At the later phase of purification water (drinking water), pH level was 7.18, which is within WHO and SLS recommended range. From raw water to drinking water, pH level increase is 11.66%. (Figure 3) Therefore the purification system can be used efficiently to purify slightly acidic water.

C. Effectiveness of step wise treatments ionic compositions

Influence of different treatment on cations and anions such as Mg+2, Na+1, K+1, Ca+2, NO3-1 are given in the Figure 4. It is evident that except NO3+1 other cation and anion concentration had no change due to different treatments. Plants have the ability to absorb most of the ions especially nitrogenous compounds for their physical activities. The aeration tank with fish and plants are helped to absorb excess of nutrient. Nitrates, Phosphates, etc. However in this system EC and TDS increase after passing through the fish and aqua plants. Here the EC increment was 20.26% in the aeration tank compared to 2nd sedimentation tank.

After oxidizing some chemicals (Ferric hydroxide) tend to be precipitated. Aeration with O2 is hazardous to anaerobic microorganisms who present in water.

D. Effectiveness of each treatment on Coli Form and E Coli levels

The filtrate comes from filter goes to drinking water tank after exposing to UV treatment. The average flow rate at the point of UV treatment unit was 3.77 l/min.

There is a significant change, of Coli form bacterial count due to UV treatment together with sand and Charcoal filtration. (Figure 6) It is 90.95% reduction of Coliform compare to raw water. According to the E coli count, there is a 100% reduction. In all other steps, there was no change in bacterial amount at 95% significant level. The water still had small quantity of Coli form bacteria. This could be further reduced by the readjustment of the exposure to UV lamps, if to eliminate the water use for drinking purposes, without including chlorination step.

Conclusions

The pH level in purified drinking water was 7.18, which is within WHO and SLS recommended range, from the raw
water to drinking water. Therefore the purification system can be used efficiently to purify slightly acidic water. Coli form count is 90.95% reduced compare to raw water and E coli count 100% reduced. Therefore bacteriological purification meets the standards.

Flow rate of the water through the system was 3.77L/min is enough for the local community to produce good quality water.

References

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Sri Lanka.

Table 1. Quality of raw ground water used for Natural water purification system

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<tr>
<th>Tank no</th>
<th>Fe (ppm)</th>
<th>Mg (ppm)</th>
<th>Na (ppm)</th>
<th>K (ppm)</th>
<th>Ca (ppm)</th>
<th>NO\textsubscript{2} (ppm)</th>
<th>NO\textsubscript{3} (ppm)</th>
<th>SO\textsubscript{4} (ppm)</th>
<th>Coli form (MPN/100ml)</th>
<th>E Coli</th>
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<tbody>
<tr>
<td>1</td>
<td>0.002</td>
<td>0.77</td>
<td>2.01</td>
<td>0.84</td>
<td>0.28</td>
<td>0.017</td>
<td>2.93</td>
<td>9.03</td>
<td>&gt;200.5</td>
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Table 2. Concentrations of some ions and bacteria in water at each treatment level

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<tr>
<th>Sample no</th>
<th>Fe (ppm)</th>
<th>Mg (ppm)</th>
<th>Na (ppm)</th>
<th>K (ppm)</th>
<th>Ca (ppm)</th>
<th>NO\textsubscript{2} (ppm)</th>
<th>NO\textsubscript{3} (ppm)</th>
<th>SO\textsubscript{4} (ppm)</th>
<th>Coli form (MPN/100ml)</th>
<th>E Coli</th>
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<tbody>
<tr>
<td>1</td>
<td>0.002</td>
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<td>2.01</td>
<td>0.84</td>
<td>0.28</td>
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<tr>
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<td>1.21</td>
<td>0.39</td>
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</table>

Average: 0.007 0.78 2.01 0.84 0.28 0.017 2.93 9.03 >200.5 0.00