

## Reviewed Paper

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## SUSTAINABLE DEVELOPMENT OF WATER RESOURCES, WATER SUPPLY AND ENVIRONMENTAL SANITATION

## Natural water purification system for local community

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*A simple household level natural water purification system to purify water to meet small family requirement. It disused with six important components including Storage, Sedimentation, Biological treatment, and Filtering, Disinfection and Drinking water storage. During the treatment process Electrical conductivity and Total Dissolved Solids values is not changed but pH is slightly increased in the bio treatment compartment due to excretion of ammonia form by the fish. A Significant change of Coli form bacterial count between UV treatment together with sand and Charcoal filter with comparing drinking water tank It is 90.95% reduction comparing with raw water E coli count is completely removed from this treatment process*

## 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 ground water 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 compare to surface water source the soil and rocks through which ground water flows screen out most of the bacteria. Never the lent on their way into ground water, bacteria may exists 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, low 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.

Purification system has consists of following sections. 1. Storage unit, 2. Sedimentation unit, 3. Biological treatment unit, 4. Filtering unit, 5. Disinfection and Drinking water storage unit.

Main storage tank and sedimentation tanks are placed in high elevation in respect to other components to avail sufficient hydraulic gradient to flow the water due to gravity from the second sedimentation tank. All the components (except pump) are non-corrosive and made up of plastic, glass and PVC.

### Main storage tank

The tank is 300l 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 hyacinth) and *Andhydrilla 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 of 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 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 (Nitrates, 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 m<sup>2</sup>/g) adsorbed the halogenated substances such as I<sup>-</sup>, Br<sup>-</sup>, Cl<sup>-</sup>, H<sup>+</sup> and F<sup>-</sup>. (<http://www.lennotech.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 shelled with shine metals to prevent UV leakage to the outside. There are two UV lamps at the UV treatment unit and one UV lamp is at the drinking water tank.

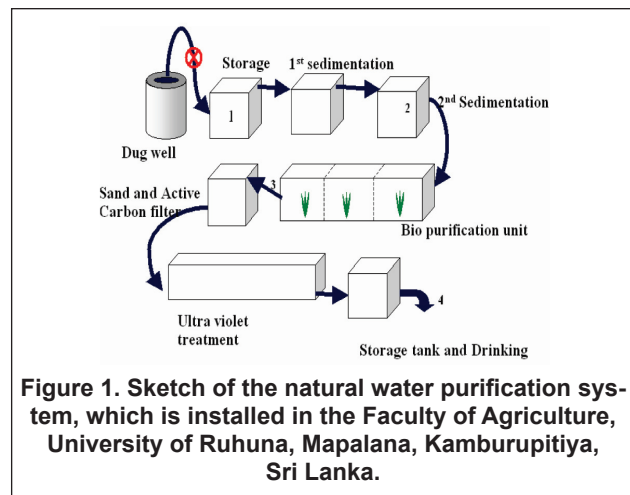
### Drinking water tank

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 discission

The quality of raw water in respect to Fe<sup>+2/+3</sup>, Mg<sup>+2</sup>, Na<sup>+1</sup>, K<sup>+1</sup>, Ca<sup>+2</sup>, NH<sub>4</sub><sup>+</sup>, NO<sub>2</sub><sup>-</sup>, NO<sub>3</sub><sup>-</sup>, SO<sub>4</sub><sup>-2</sup>, Coli form, E coli prior to the treatment by the water purification is given in the Table 2.



**Figure 1. Sketch of the natural water purification system, which is installed in the Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka.**

According to the results of the above system water quality parameters, water source is suitable for drinking purposes in respect to mineral contents. However 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.

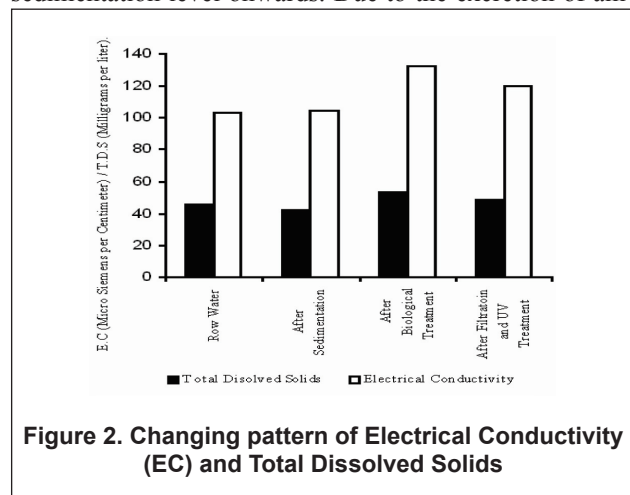
### A. Effectiveness of step wise treatments on electrical conductivity and total dissolved solids

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 wise 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 through the bio treatment unit. The reasons for the pH increment may be the reduction of NO<sub>3</sub><sup>-1</sup> level at the sedimentation level onwards. Due to the excretion of am-



**Figure 2. Changing pattern of Electrical Conductivity (EC) and Total Dissolved Solids**

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 H<sub>2</sub>S, CO<sub>2</sub> and Cl<sub>2</sub> 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<sup>+2</sup>, Na<sup>+1</sup>, K<sup>+1</sup>, Ca<sup>+2</sup>, NO<sub>3</sub><sup>-1</sup> are given in the Figure 4. It is evident that except NO<sub>3</sub><sup>+1</sup> 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 O<sub>2</sub> 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

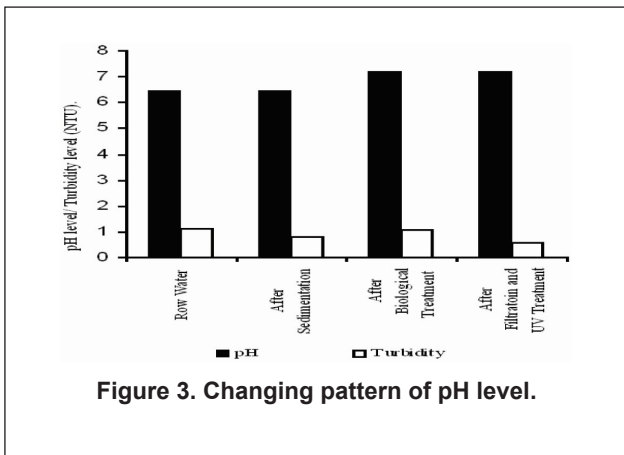


Figure 3. Changing pattern of pH level.

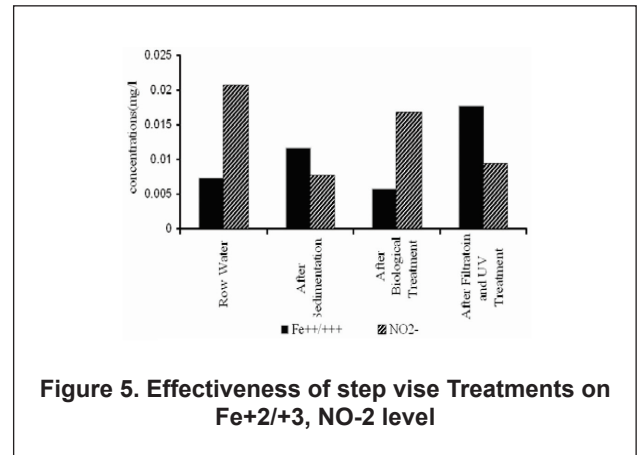


Figure 5. Effectiveness of step wise Treatments on Fe+2/+3, NO-2 level

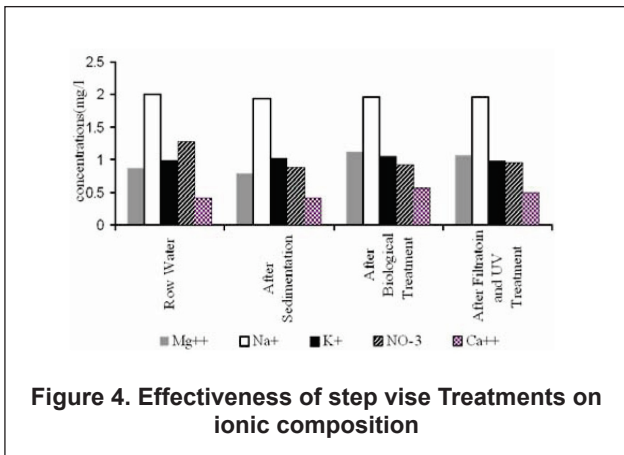


Figure 4. Effectiveness of step wise Treatments on ionic composition

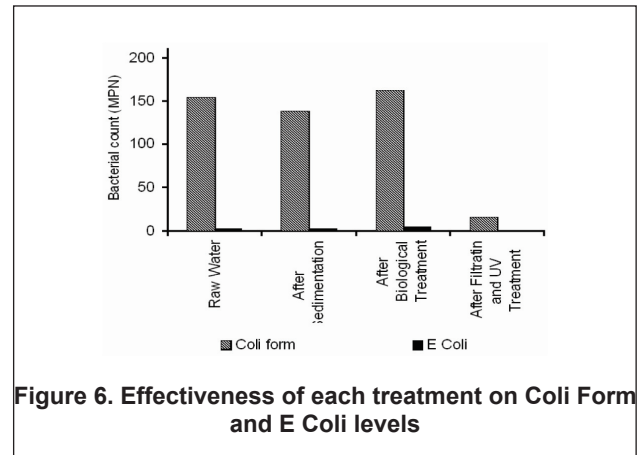


Figure 6. Effectiveness of each treatment on Coli Form and E Coli levels

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

| Tank no | Fe (ppm) | Mg (ppm) | Na (ppm) | K (ppm) | Ca (ppm) | NO <sub>2</sub> <sup>-1</sup> (ppm) | NO <sub>3</sub> <sup>-1</sup> (ppm) | SO <sub>4</sub> <sup>-2</sup> (ppm) | Coli form (MPN/100ml) | E Coli |
|---------|----------|----------|----------|---------|----------|-------------------------------------|-------------------------------------|-------------------------------------|-----------------------|--------|
| 1       | 0.002    | 0.77     | 2.01     | 0.84    | 0.28     | 0.017                               | 2.93                                | 9.03                                | >200.5                | 0      |
| 2       | 0.002    | 0.73     | 1.93     | 0.84    | 0.30     | 0.007                               | 2.30                                | 15.35                               | >200.5                | 1      |
| 3       | 0.008    | 1.18     | 1.92     | 0.78    | 0.49     | 0.022                               | 2.72                                | 13.33                               | >200.5                | 6.4    |
| 4       | 0.032    | 1.04     | 1.94     | 0.93    | 0.35     | 0.013                               | 2.68                                | 14.35                               | >200.5                | 0      |
| 1       | 0.003    | 0.75     | 1.96     | 1.00    | 0.39     | 0.042                               | 0.20                                | 10.07                               | 129.8                 | 5.3    |
| 2       | 0.012    | 0.88     | 1.95     | 0.92    | 0.39     | 0.012                               | 0.08                                | 8.25                                | 118.4                 | 3.1    |
| 3       | 0.003    | 1.16     | 2.03     | 0.88    | 0.63     | 0.022                               | 0.02                                | 7.92                                | >200.5                | 3.1    |
| 4       | 0.007    | 1.13     | 1.97     | 0.96    | 0.59     | 0.012                               | 0.08                                | 10.07                               | >200.5                | 0      |
| 1       | 0.017    | 1.21     | 2.03     | 1.31    | 0.40     | 0.003                               | 0.68                                | 9.79                                | 129.8                 | 0      |
| 2       | 0.028    | 0.79     | 1.96     | 1.38    | 0.43     | 0.004                               | 0.24                                | 8.95                                | 165.2                 | 1      |
| 3       | 0.006    | 1.15     | 1.94     | 1.34    | 0.69     | 0.006                               | 0.00                                | 6.98                                | >200.5                | 2      |
| 4       | 0.006    | 1.10     | 1.96     | 1.12    | 0.55     | 0.003                               | 0.08                                | 7.24                                | 16.4                  | 0      |
| 1       | 0.007    | 0.74     | 2.02     | 0.84    | 0.56     | -                                   | -                                   | -                                   | -                     | -      |
| 2       | 0.005    | 0.77     | 1.89     | 0.94    | 0.47     | -                                   | -                                   | -                                   | -                     | -      |
| 3       | 0.007    | 0.98     | 1.94     | 1.21    | 0.39     | -                                   | -                                   | -                                   | -                     | -      |
| 4       | 0.027    | 0.96     | 1.96     | 0.89    | 0.42     | -                                   | -                                   | -                                   | -                     | -      |

**Table 2.** Concentrations of some ions and bacteria in water at each treatment level

| Sample no | Fe (ppm) | Mg (ppm) | Na (ppm) | K (ppm) | Ca (ppm) | NO <sub>2</sub> <sup>-1</sup> (ppm) | NO <sub>3</sub> <sup>-1</sup> (ppm) | SO <sub>4</sub> <sup>-2</sup> (ppm) | Coli form (MPN/100ml) | (MPN/100ml) |
|-----------|----------|----------|----------|---------|----------|-------------------------------------|-------------------------------------|-------------------------------------|-----------------------|-------------|
| 1         | 0.002    | 0.78     | 2.01     | 0.84    | 0.28     | 0.017                               | 2.93                                | 9.03                                | >200.5                | 0.00        |
| 2         | 0.003    | 0.75     | 1.96     | 1.00    | 0.39     | 0.042                               | 0.20                                | 10.07                               | 129.80                | 5.30        |
| 3         | 0.017    | 1.21     | 2.03     | 1.31    | 0.49     | 0.003                               | 0.68                                | 9.79                                | 129.80                | 0.00        |
| 4         | 0.007    | 0.74     | 2.02     | 0.84    | 0.56     |                                     |                                     |                                     |                       |             |
| Average   | 0.007    | 0.87     | 2.01     | 1.00    | 0.41     | 0.021                               | 1.27                                | 9.62                                | 153.30                | 1.77        |

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.

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