A Comparative Study of hand operated Water Purifier

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Abstract
The present work shows the comparative analysis of various designs of portable water purifier without consuming electric power. Four different combinations of reverse-osmosis membrane, alum, potassium permanganate, sodium tri chlor has been used for obtaining optimized value of total dissolved solids (TDS) of the known sample of water. In the subsequent stages of the project the various components of the product will be designed and fabricated. The quality of the water filtered by the prototype device depends upon the membrane (filter) it is using so the proper designing and selection of the filter is also a very crucial task. The specialty of the product is that it is a compact product hence can be easily carried to anywhere. Its operation is very easy so it can be operated by anyone with ease.

1. Introduction
Since water is a necessity of life, it is important to drink water free from contaminants. The quality of usable water is deteriorating with time. It may be due direct disposal of industrial and household waste into the water bodies or the increasing level of pollution, which directly affect people’s health and hygiene. There is an urgent need to address this problem at all possible levels to ensure the availability of safe drinking water. To treat water and make it worth drinking, different processes are used and one of the best treatment methods is reverse osmosis (RO). In this process of micro filtration, the water goes through semi permeable membranes with minute pores and becomes free of contaminants. The impurities left behind are flushed out [1].

The reverse osmosis in the treatment of drinking water is a useful technique. It is suggested to do pre-filtration before going for the reverse osmosis process. It occurs when the water is moved across the membrane against the concentration gradient, from lower concentration to higher concentration. To illustrate, imagine a semipermeable membrane with fresh water on one side and a concentrated aqueous solution on the other side. If normal osmosis takes place, the fresh water will cross the membrane to dilute the concentrated solution. In reverse osmosis, pressure is exerted on the side with the concentrated solution to force the water molecules across the membrane to the fresh water side [2].

The reverse osmosis systems that have a five stage systems. The first stage is the removal of sediments like clay, silt and stones from the water. The second stage of the Reverse osmosis treatment is the usage of carbon filter. The carbon filter is used to remove the chlorine and other harmful chemicals that enter the water sources. In third stage, water is passed from a dense and compacted carbon filter. The water that we get may have some unpleasant characteristics and this third step helps in the removal of all such characteristics. All the contaminants left in the water are removed at this stage and water becomes almost clean. In the fourth step, water passes through the membrane and all the heavy metals present in the water are removed. In this last stage, the bacteria, chlorine, and bad odor are removed from water. After water passes from this stage, it comes out of the faucet and is perfect for consumption [3].

There are various water treatment processes that can be implemented. The processes like chlorination, sand filtration, coagulation, Flocculation, sedimentation plus filtration, microfiltration, ultrafiltration, nano filtration. Chlorination is for removal of odor and some particles only. Sand
filtration is a natural process which purifies the water in the natural bodies of water. Coagulation is addition of alum to the water to settle down the particles which are there in on the surface of water. Sedimentation is the process in which the particles settles down on its own. Microfiltration, ultrafiltration, nano-filtration are defined with respect to the size of grains used in the filters [4].

Pressurized system has been used for the removal of the bacterial and protozoans impurities along with the removal of the dissolved salts in the water. It is used for the treatment of sea water and brackish water (water containing dissolved salts more than the sea water). According to technical suggested measures, the total dissolved salts in the water should be less than 1000mg/l of water, and according to the W.H.O specifications, the TDS should be less than the 250mg/l of water [5].

2. Method of Treatment
In the current work, a hand operated water purification unit is designed, fabricated and tested for output water quality. Four different designs have been tried, one using the commonly available kitchen press, another one based on the pickkari or color sprayer, other two hand operated water purifiers are also designed and developed. The TDS tests were performed for the initial design and the results of these tests have been quite encouraging to go for the final refinement of the design. The optimization of these later developed models has also been attempted. Many components of the equipment such as filter (membrane), cylindrical container, top cover with piston, upper and lower strainers are designed so that a final and efficient product can be developed. Also, the weight and cost of the product are kept in consideration. Fig. 1 shows the drawing of kitchen press press, color sprayer, bottom strainer and cylinder-plunger arrangement used for hand operated water purifier. The top and bottom strainers will remain same in shape for all the designs. The only change for the top and bottom strainers will be in their sizes.

The top and bottom strainers support the filters and perform the primary cleaning by removing the suspended particles and prohibiting these from entering into filters.

![Fig 1. Kitchen press, color sprayer, bottom strainer and cylinder-plunger arrangement used for hand operated water purifier](image)

**Bottom Strainer**
This is the main support to the filtering layers. First it supports the filter which is placed in between the top and bottom strainers and second function it performs is the help in the purification of water and it has holes in it of somewhat bigger in size than the holes in top strainer to allow the ease in the flow of water and also to reduce the required pressure to be applied through the rotation of the crank for the flow of water.

**Top Strainer**

It is there in the equipment to perform the pre-filtration function mainly. It also supports the filter placed in between the top and the bottom strainers but main function is to do pre-filtration. It has some chemical sprayed over it to destroy the dissolved bacteria, pathogens in the water and it has holes of smaller sizes to separate the particulate materials from the water and to prohibit them going into the filter because these particulate matters can choke the filters and it can make the filter to stop doing its work.

**First Design Result**

![Graph showing TDS values](image)

Some defects were found in this design, which were difficult to eliminate. The unevenness in the graph between no. of filters and TDS value is attributed to the following problems:

1. Leakage from the base part of the equipment.
2. Inefficient working or poor working of the equipment.
3. Inefficient pressure generation which is needed for proper working.

Second design Result

| NO. of Filters | Location1 | Location2 | Location3 |
|----------------|-----------|-----------|-----------|
| 2              | 650       | 630       | 610       |
| 3              | 601       | 590       | 530       |
| 4              | 567       | 515       | 501       |
| 6              | 475       | 490       | 450       |
| 8              | 325       | 360       | 340       |

As compared to the initial design, the pressure developed is more, which is resulting in the lower value of final TDS for the same value of the number of filters. As there is still unevenness in the graph. So, there is still some problem of leakage from the basal part of the equipment.

Third Design Result

| NO. of Filters | Location1 | Location2 | Location3 |
|----------------|-----------|-----------|-----------|
| 2              | 618       | 620       | 625       |
| 3              | 590       | 595       | 576       |
| 4              | 445       | 460       | 451       |
| 6              | 375       | 360       | 368       |
| 8              | 279       | 267       | 253       |
There is a little bit of unevenness in the graph which can be attributed to the leakage occurring from the bottom and top of the equipment. The values of TDS after 2, 3, 4, 6, 8 membranes do not depend upon the initial values of TDS being taken for the purification.

**Features of Final Design**

1. A detachable input is provided to properly supply water to the cylindrical container without opening and closing the top of the equipment time and again.

2. Cylindrical container is made into two parts and threads are provided so as to allow the ease in cleaning the filters and to optimize the design for efficient working of the equipment.

**Fig 2.** Final improved design for hand operated water purifier

**Improved Design Result**

| NO. of Filters | Location1 | Location2 | Location3 |
|----------------|-----------|-----------|-----------|
| 2              | 621       | 614       | 609       |
| 3              | 540       | 535       | 528       |
| 4              | 430       | 428       | 423       |
| 6              | 312       | 369       | 307       |
| 8              | 210       | 266       | 203       |
Result and Discussion

The outcome of final improved design over the other three are:

1. The cylindrical container is made into two parts to facilitate the easy cleaning of the filters and to dismantle it when it is not being used, so that it can be easily carried in the bags.

2. It is compact in its design & therefore can be used anywhere during journey, camping, during patrolling.

3. A detachable input is also provided so that the water can be easily filled into the container without removing the piston time and again from the cylindrical container.

4. It is simple in construction and can be operated with ease by anyone.

5. The saturation value of TDS for the existing design is approx. 210 PPM.

Conclusion

1. The values of TDS after 2, 3, 4, 6, 8 membranes do not depend upon the initial values of TDS being taken for purification.

2. Since all the graphs of the improved designs are almost identical, we can conclude that there is no leakage from the equipment and the final value of TDS is independent of the initial value of TDS being taken for the purification.

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