A Fuzzy Based Ultra-Nano Water Purification Technique

Gayathree.K, Rajkumar.S, Arul Murugan, Banuselvasaraswathy.B

Abstract: ***Water is an essential factor for all living organism in the world. But the polluted atmosphere results in the contamination of water. The water may be contaminated with impurities like dissolved salts, dust particles and especially the presence of various microorganism such as bacteria, virus etc. The occurrence of these pollutants causes several health issues. So it becomes vital to purify the water before consuming. There are various water purification methods available today like RO, UV, UF, RO+UV, RO+UV+UF etc. However every method possesses some drawbacks. The motive of the proposed ultra-Nano purification method is to provide an efficient water purification method which provides pure water suitable for drinking along with essential minerals. In addition it also overcomes the drawback of present techniques.***

Keywords: Reverse Osmosis (RO), Ultra Violet Rays purification (UV),Ultra Filtration (UF),Total Dissolved Salts (TDS) and Ultra-Nano Purification (UN).

I. INTRODUCTION

Water is vital for both animals and plants for their survival. 75% of human body composes of water. An average adult body consists of 42 liters of water, with just a small loss of 2.7 liters it would result in dehydration of the body which in turn results in symptoms of irritability, fatigue, nervousness, dizziness, weakness, and headaches and will consequently reach a state of pathology. So water intake is very essential than food.

In today's world the purity of water is at major risk. Due to the urbanization of the world the natural resources of water has been polluted to an extreme level. The river which is the major water source is polluted mainly by the addition of chemical wastes from the industries. This results in the occurrence of toxic salts and chemicals in the drinking water. Apart from this the dead and decayed animal wastage which is present in the water results in the occurrence of various harmful microorganism like virus, bacteria etc. The green algae may also affect the purity of the water in the water sources.

The presence of impurities in water may be the cause of several health hazards. Water borne diseases are caused by drinking polluted or contaminated water which is the root cause of various types ofdiarrheal diseases including cholera, typhoid and dysentery. Around 3.4 million deaths yearly are due to water borne diseases. So water treatment has become the important. There are several water treatment methods [3,7&10], whose goal is to purify the contaminated water and making it suitable for intake. Water treatment is nothing but the process of purifying dirty water using any purification methods. The basic methods include sedimentation, ion exchange, filtration and membrane based filtration. The membrane filtration includes RO, UF, NF etc. The purification using ultraviolet ray [4] is the common method used in homes to obtain pure water. This method destroys the entire microorganism present in the water. The major disadvantage of this method is that the dead bodies of the microorganism will be retained in the water. The water to be treated with UV method must be clear so that it will not block any rays to penetrate the water. If the water is muddy it will not allow the light to pass through and thus the microorganism is not destroyed properly. An additional problem in this approach is that it will not remove the dissolved salt from the water.

The Reverse Osmosis (RO) [1, 9] is the membrane based purification technique in which the pressurized water is made to flow through the semi- permeable membrane, which blocks the entire microorganism and dissolved salts present in the water. The tap water cannot be used directly since the RO requires the water to strike the membrane with high pressure. So,extra electricity is used to boost the pressure of tap water. Moreover this method operates on clear water, thus a pre-filtration setup is essential. One of the major limitations of RO method is the amount of waste water. If 5 lit of water is fed into the system only 2 liters of pure water is obtained at the outlet while the remaining 3 lit is the waste water.

Ultra filtration [2] is also a type of membrane purification method. Unlike RO this method operates on normal tap water. It does not require additional electricity to pressurize the water. The advantage of UF [6&8] is that it can operate on turbid water thus no need any pre-filtration set ups. The UF method overcomes the drawback of UV i.e. it not only destroys the microorganism but also removes the dead bodies from the water. The drawback is that it cannot remove dissolved salts from the water. Nano filtration [5] is the latest purification technique used. Its membrane size is between RO and UF. It working is similar to RO, but unlike RO it works on normal tap water and hence no need any extra energy to pressurize the water. This method removes microorganism completely and dissolved salt partially from the water. The main advantage of NF is the reduction of waste water content from the system.

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In addition it overcomes bio-fouling that normally occurs in the membrane purification method.

The proposed ultra-nano method combines the advantage of both UF and NF to provide a more efficient water treatment technique which overcomes all the drawbacks of the above mentioned methods and at the same time it automatically retain the essential minerals in the water without the need of any extra de-mineralization and re-mineralization setups. The most interesting factor of the proposed technique is the fuzzy control unit which will optimize the system performance and also reduces the energy consumption.

II. ULTRA-NANO PURIFICATION METHOD

The ultra-nano purification is a type of membrane purification method which includes two stage of purification. The first stage consists of ultra-porous membrane followed by the second stage which includes nano-porous membrane. The ultra-porous membrane is used as the first stage so that it operates at both tap and turbid water and hence no pre-filtration is required as RO. The water from this stage will be free from microorganism but it will retain all the dissolved salts in it. The dead bodies are also removed from the water. This water is then made to flow through the second stage where the dissolved salts are removed partially i.e. only the monovalent salts are allowed to pass through the membrane while the divalent salts are blocked.

The main advantage of using this method over other membrane purification like RO is that it overcomes bio-fouling. The wetness in the membrane may result in the formation of algae over it and thus the performance of the system is affected. This process is called bio-fouling. The UN purification results in 75% of TDS reduction retaining the essential minerals.

A. Working of UN Purification Method

The proposed UN purification method is shown in figure 1.This method works on all sort of water like tap water, water from permanent storage or ground water. The water is first send to a temporary storage tank which checks the state of water with the help sensor present in it. The fuzzy control unit receives the signal from the sensor. In the fuzzy unit a set of membership functions are formulated which controls the valves present in the UN system.

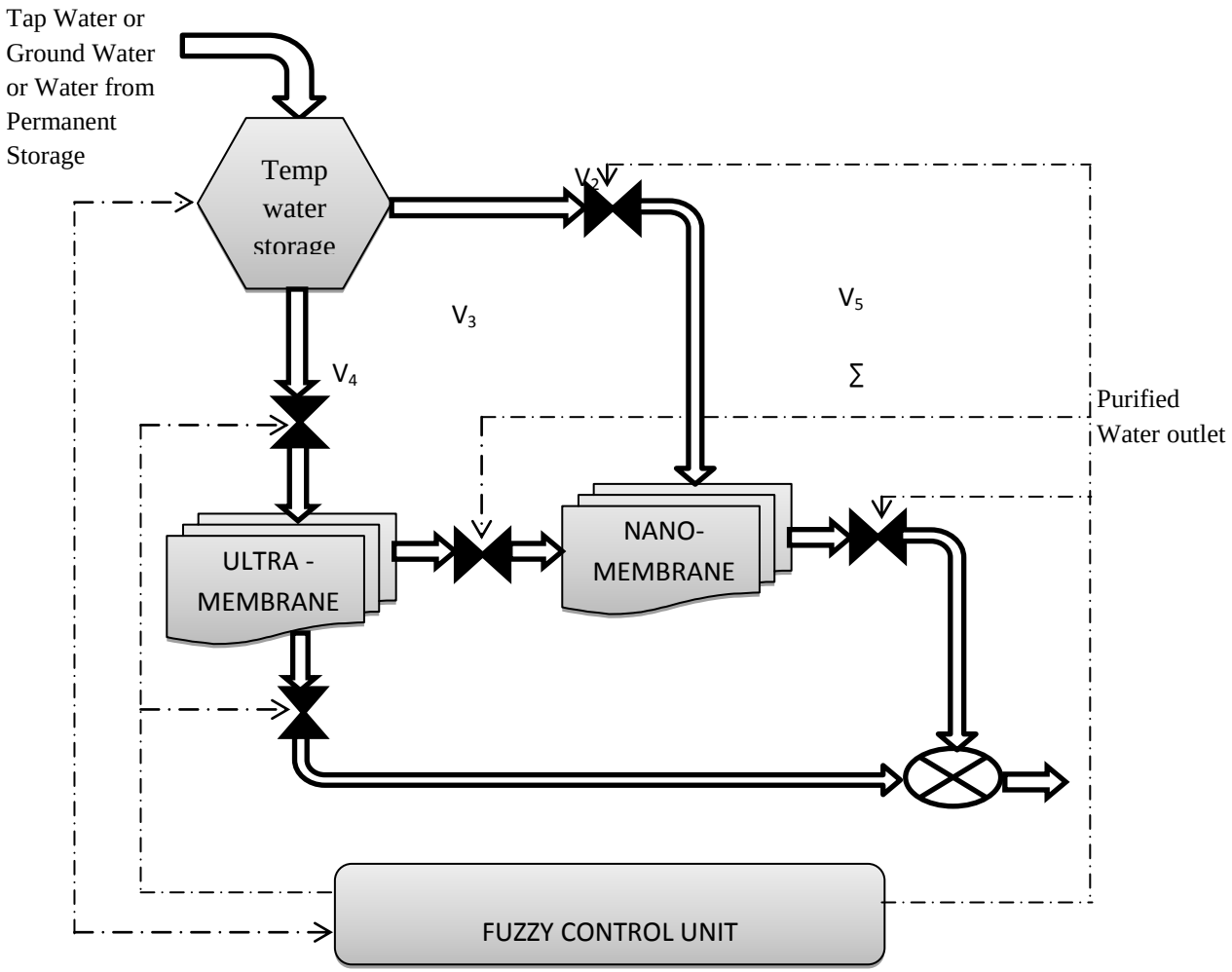

Fig. 1 Block Diagram of UN Purification Technique

There are three membership function in the fuzzy control unit, the first function (M_1) is applicable when the water is muddy with only microorganism, second function (M_2) is applicable when the water is salty with only microorganism and the third one(M_3) is when the water is turbid and consists of both dissolved salts and microorganism. Once the water enters the temporary storage tank the sensor in it will detect the nature of it and activate the corresponding member function.

When the member function $M_1$is activated it will open the valve V_1 and V_4. Thus the water will flow only through the ulta-porous stage of the UN system which is sufficient to provide pure water with the removal of entire microorganism. When the function $M_2$is activated it will open the valve V_2 and V_5. The water will be made to flow through the Nano-porous stage of UN system which provides pure water with complete removal of microorganism and almost 75% reduction of dissolved salts retaining only the essential monovalent salts(which plays a vital role in the body metabolism). When the member function M_3 is activated it will cause the valve V_1, V_3 and V_5 to open. When the water flows through the ultra-porous stage, the microorganism along with its dead bodies are removed from it. Then the micro-organism free water is then made to flow through the nano-porous stage which removes the dissolved salts in it. A common outlet is used to obtain the purified water from the UN system which is most suitable for drinking.

III. RESULTS AND DISCUSSION

When the reduction level of microorganism is considered the UN and UF system provides 100% reduction when compared to other methods like RO, NF and UV. The comparison in the context of microorganism reduction is shown in figure 2.

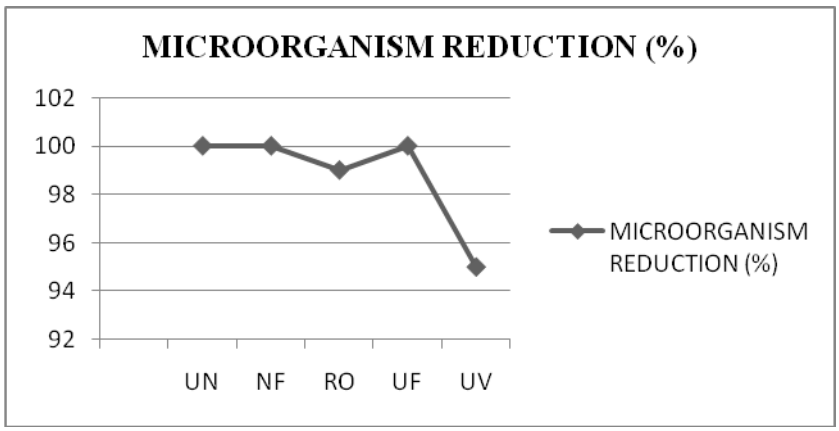

Fig. 2 comparison of microorganism reduction of Various Purification Methods

The second comparison is based on the TDS reduction capability of various methods. The percentage of TDS reduction of various methods is shown in figure 3. Among which the RO possess a high reduction rate of 100% compared to all methods while the proposed UN system results in 75%.

The next comparison is based on the amount of waste water from the purification systems. Among which RO have more wastage compared to all methods and our proposed technique possess no wastage which is the major advantage of it. The comparison of various methods regarding water purification is shown in figure 4.

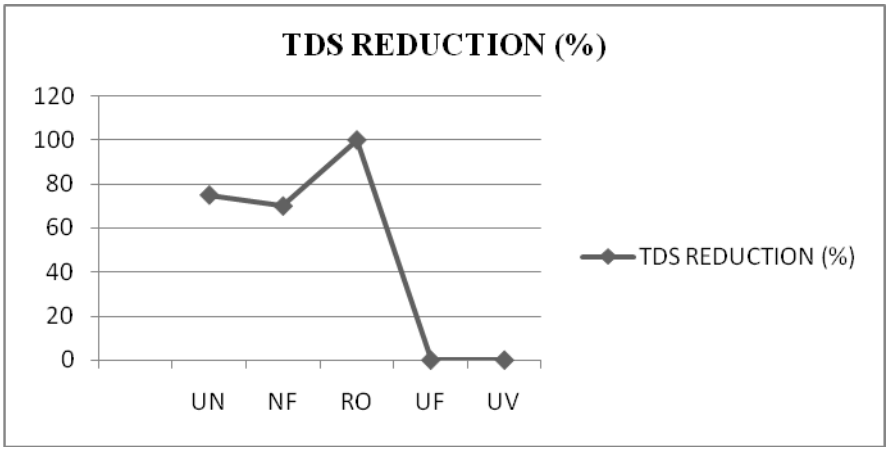

Fig. 3 Comparison of TDS reduction of Various Purification Methods

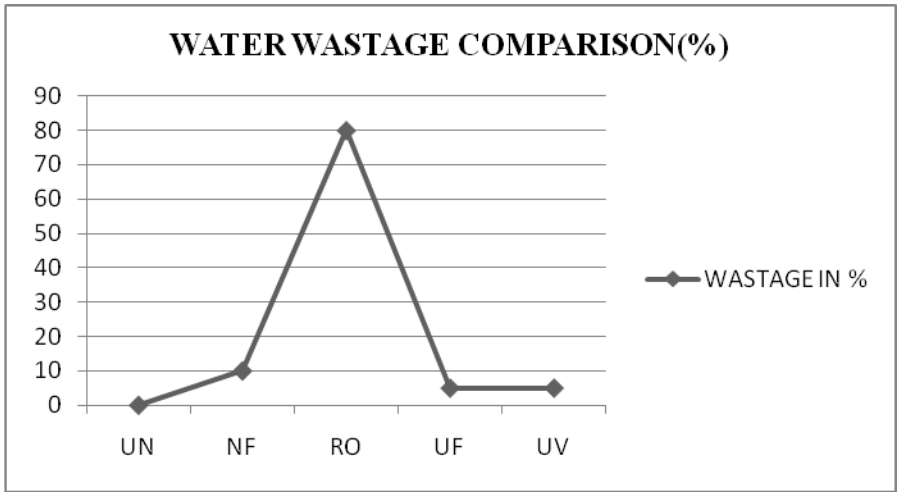

Fig. 4 comparison of water wastage of Various Purification Methods

The next comparison is based on the energy consumption of various purification techniques in order to carry out the purification process. The comparison chart is shown in figure 5, in which the proposed method consumes very less energy compared to RO which consumes more amount of energy.

The final comparison is the efficiency comparison of various purification methods. The efficiency is considered based on the ability of the water to drink. It is obvious that the proposed UN system have the highest efficiency compared to the other techniques. The efficiency comparison is shown in the figure 6. The table 1 gives the consolidated values of various comparisons.

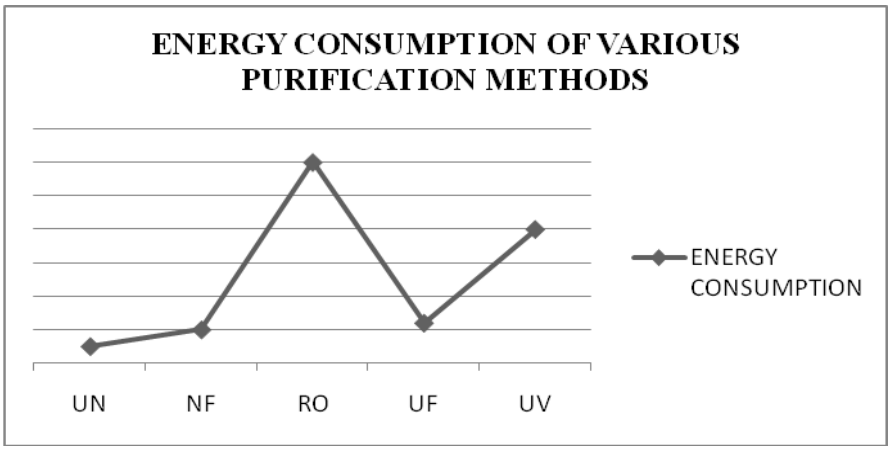

Fig. 5 Energy Consumption of Various Purification Methods

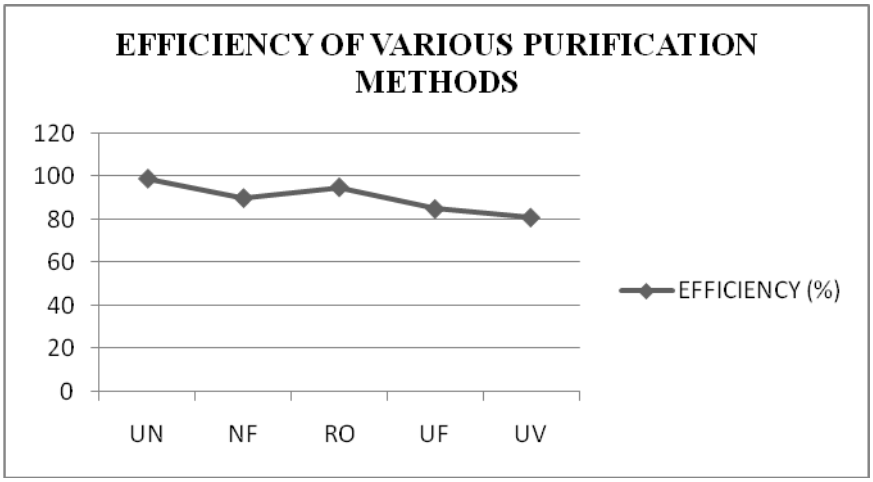

Fig.6 efficiency comparison of Various Purification Methods

IV. CONCLUSION

The proposed Ultra-Nano purification method is found to be more efficient than all other existing methods in every aspect. Among which the main one is the overcoming of bio-fouling which is present in the RO method. It completely removesthe entire microorganism present in the water along with their dead bodies and hence the percentage of microorganism removal is 100%.The overall efficiency of UN method is 99% which is 4% more than the RO (which is the considered to be the most efficient method). It is capable of working with turbid water unlike RO which requires pre-filtration setup which in turn reduces the power consumption. Another important advantage is that there is no water wastage (0%wastage of water) in this methodi.e. 100% conversion of impure water into pure water is achieved. It retains the essential minerals like sodium which plays a vital role in body metabolism and removes the toxic chemicals like calcium and magnesium. Since it automatically retains the essential minerals there is no need to use a separate de-mineralization and re-mineralization setups. Hence there is no need of extra energy and results in very less energy consumption compared to other methods.

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