IoT Based Approach For Recycling And Reusing Grey Water By Two-Phase Distillation Technique

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Abstract:

The Two - Phase distillation tube is used to purify the grey water which is considered to be waste sewage that drained out from all kind of houses and industries. The waste sewage water is usually let directly to the local sewage drain which is pipelined to rivers and obviously the river water is polluted and even marine life also affected in a large scale. When such polluted river water is used to grow crops that results in unhealthy crops and harmful food products which certainly causes injurious to human health. This problem can be addressed by a Two - Phase distillation tube methodology. The distillation tube will filter all the sewage water before it reaches the local drain. This water can be purified and made reusable again or it can be let to the local drains to river so that river pollution can be avoided. The purification is possible with the help of mechanical filters such as Nanofiltration filter and Reverse Osmosis filtration (RO) filter. Since bacteria and micro-organisms are filtered, these filters blocks them passing through it for which a customized design is used with these filters that performs efficient purification. This entire system also includes a mechanism to separate waste solid particles, the extracted solid waste is collected and that can be converted into manure and used for agriculture. The main problem focused is water purification and river pollution control which would be very efficient and smart method to recycle waste water and reuse by way of two phase distillation technique which can also referred to be two stage purification. The complete system can be made Internet of Things (IoT) based and the physical condition or status of the system can be monitored online as variety of sensors are associated so that maintenance notification alerts can be pushed to the subscribed customers.

Keywords: Two- Phase distillation tube, Nanofiltration filter, Reverse Osmosis filtration filter, Water purification.

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1. INTRODUCTION

As we know our earth has about 1,386 Billion km^3 area of water body with 97.5% being salt water means sea water which is non-usable or drinkable form, only 2.5% of fresh water and out of that only 0.3% is in liquid state i.e usable form [1]. This 0.3% of usable water is available from rivers, if waste sewage water is let directly to the river through local drains then river water will be polluted and even marine life is also affected. Such polluted river water certainly leads to harmful crop ups in agriculture, hence polluted water must be treated. Conversion of waste water into reusable water can be achieved by means of filtration and purification methodology with the support of IoT technology for segregation of large solid waste particles in the sewage water, and separate all kind of bacteria or micro-organisms and purification using nanofiltration filter and RO filter.

In the modern purification system, there are large water treatment plants which take complete waste water to one place and water is filtered in a large quantity that requires multiple steps for purification which takes a lot of processing and if the water treatment plant fails, then large quantity of water will not be purified in time. The main disadvantages of water treatment plants are cleaning is hassle,

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most plants need at least three large tanks for maintenance, temperature changes affect the tank greatly. If in any case the main treatment plant break then the sewage water may reverse back to the entire premises. If the plant cannot pass water through defined stages, then it backs up through the filtering system and that leads to property damage and also waste water will mix with recycled water. So all such issues can be addressed by a two-phase distillation tube method as it purifies the waste water at its origin only which makes it more safe and effective method of purifying the water. The main motivation for this proposal is to purify grey water for reusability and clean the river water to avoid river water pollution and also to save the marine life otherwise fishes in the river feed the same polluted water that harm health of the fishes too, farmers grow infected crop ups, green leaves. When people consume such fishes and foodstuff that becomes harmful food and spoil human health, hence it is required to be wise with the existing water purification system so that we can plan for making a better future and save nature.

2. RELATED WORK

There are varieties of water purifiers available in the market that are used to just purify regular drinking water. In these types of filters, components used are inline sediment filter (5-micron size), inline carbon block filter, UF (ultra-filtration) membrane cartridge, UV (ultra-violet) disinfection cartridge, adapter, float switch, solenoid valve, UV lamp, storage tank. Here are the 10 common types of water filtration system at home they are, Sediment Filtration, Activated Carbon Block (ACB) Filtration, Granular Activated Carbon (GAC) Filtration, Reverse Osmosis (RO) Filtration, Distillation, Ion-Exchange (IX), Ultraviolet (UV) Disinfection, Ultrafiltration (UF), Activated Alumina (AA) Filtration, Ionization[2]. The lifetime of these type of water filters is 10 to 15 years with replacement of filters and clean them frequently. Meanwhile there are water treatment plants which collect all the sewage water through local drains all at once in a place and then purify the large quantity of water at the same time. The main steps involved in water treatment plant are collection, Screening and Straining, Chemical addition, Coagulation and Flocculation, Sedimentation and Clarification, Filtration, Disinfection, Storage, and finally Distribution are done respectively [3]. With this, normal water is filtered and used for drinking and cooking food even though the water is purified in water treatment plants but, still people use water filters for their day to day living, which does not make much logic. The process of water purification at water treatment plants starts from collecting the sewage water from homes to the water treatment plant location, this requires the installation of long pipes to transport the water and even local drains are required, but after the cleaning process is done at the water treatment plant that clean water is redirected back to homes for regular usage. While pumping the purified water back to the homes, the pipelines may break at some point or may cause any problem which will lead to leakage of purified water or the purified water might get contaminated also. Another type of purification system was being introduced that is 'the multi-stage organic water filter system'. Here the purification system is robust, sustainable and modular system for water purification. This product purify the waste water with the help of plants, these plants are ideal for treating the water flowing through them. This can happen only when the waste water contains organic waste such as food residue, animal wastes, cooking wastes etc, but it cannot purify the chemicals which comes from soap, shampoo or detergent waste water and this is the limitation of this project. This project could be made use in water treatment plants also or it could be a separate filtering system all together. The results of this project were a very good improvement in the quality of processed water [4].

Automation of the water treatment plant is also being approached, which is done by 'raspberry pi' at water treatment plant. This project uses raspberry pi as an alternate to Programmable Logic Controller for automation. The raspberry pi makes the controlling better and even more efficient as it is like a mini-computer though it is basically a microprocessor. The main limitation of this work is that it just makes the present system easier but it cannot reduce the filtering processes or it does not improvise the efficiency of the purification process and it does not modify the filtering system. The results of this project were that if the raspberry pi is integrated into water treatment plant then the controlling of the water treatment plant will be more efficient [5]. All such limitations motivates to propose a better filtering system which is more efficient and eco-friendly, and can filter chemical waste and organic waste as well which are produced at our home. All such issues can be addressed by a Two-phase distillation tube as it purifies the waste water at its origin only this makes it more safe and effective method of purifying the water.

3. WORKING METHODOLOGY

I. Technical specifications and filters that are used regularly

As the size of the water molecules is very much smaller than the bacteria, virus, fungus and all pathogens. The Nanofiltration and RO filtered molecules are of size more than water molecules and less than all the bacteria, virus, fungus and all pathogens. Hence, leaving all the impurities behind when filtered through water.

a) Bacteria, virus and pathogens size

Bacterial cells are very small - about 10 times smaller than most plant and animal cells. Most bacterial cells range in size from 0.2 to10 microns or micrometers (0.0000079 to 0.00039 inch). Common Escherichia coli or E coli, bacteria are rod-shaped bacteria, 1 micron by 2 microns long. General characteristics of Plasmodium falciparum are mainly it is a blood borne parasite. It exists in two forms – Asexual form and Sexual form, former is usually ring shaped and 1-2 microns in size and latter is like amoeboid and band forms. HIV is different in structure from other retroviruses. It is roughly spherical with a diameter of about 120 nm, around 60 times smaller than a red blood cell.

b) Water size

The diameter of a water molecule (H_2O) is closely calculated to be about 0.000282 μm (micrometers – millionths of a meter) in diameter. This number (0.000282 μm) may be referred as: “282 millionths of a micrometer” (or micron). In understanding the size of water molecules, it’s important to know that the shape and size of an individual water molecule which is not a perfect sphere. The oxygen atom is flanked on either side by two hydrogen atoms at an angle of about 104.45 degrees. The distance from the center of the oxygen atom to the center of one of the hydrogen atoms is about 95.84 pm (picometers – trillionths of a meter), which equals 0.0000958 μm (micrometers, or microns).

c) Nanofiltration filter and RO filters size

A nanofiltration filter has a pore size around 0.001 micron. Nanofiltration removes most organic molecules, nearly all viruses, most of the natural organic matter and a range of salts. Nanofiltration removes divalent ions, which make water hard, so nanofiltration is often used to soften hard water. Nanofiltration filter is a membrane filtration- based method that uses nanometres sized through-pores that pass through the membrane easily and properly. Nanofiltration membranes have pore sizes from 0.001-0.01 micron, smaller than that used in microfiltration and ultrafiltration, but just larger than that in reverse osmosis. Reverse osmosis filters have a pore size around 0.0001 micron. After water passes through such filter, it is essentially pure water. In addition to removing all organic molecules/ viruses, reverse osmosis also removes most minerals that are present in the water. Reverse osmosis removes monovalent ions, which means that it desalinates the water. To understand how reverse osmosis works, it is helpful to understand osmosis. The pore size of RO membrane is 0.0001 microns which is smaller than the size of the Sodium Chloride Molecule which is 0.0007 micron and will not let it through.

II. Description of the product

Firstly, the filters are of 2 types, metallic mash of reasonably small sized holes, and filters of nanofiltration and RO filters, filter out all the solid mass and all the bacteria of all kind respectively, from household waste water which is let out from the sanitary pipe to the sewage line for recycling of that water. the solid material that is settled on the metallic mesh is collected in the waste collector box placed below the mesh, by pushing it down by the top pusher placed above the pipe.

The Rubber tube connector is used to connect the regular pipe with the Two-phase distillation tube shown in Figure 3.1. It is mainly connected to avoid the water lose between the two pipes, it also makes connection easy and fast to install and also reduces the maintenance cost of fixing the two pipes together.

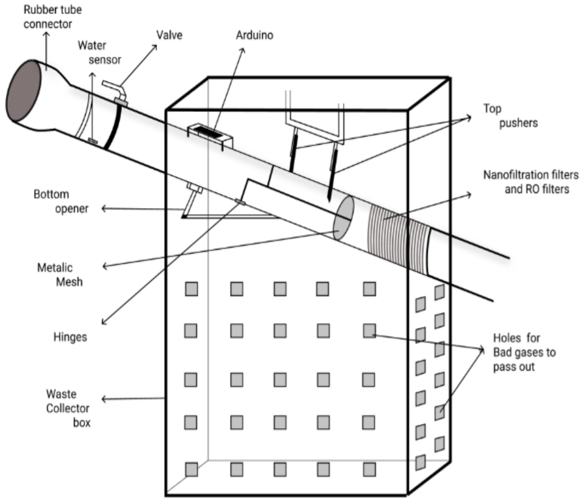

Figure 3.1: Design of the Two-phase distillation tube

Secondly, the action of top pushers and bottom openers are controlled by Arduino at a very precise interval of time which can be relative depending on the satiation and condition of the flow of water through the pipe. The top pushers remove all the solid dirt which is deposited on the metallic mesh by smoothly rubbing it on its surface and will eventually push the solid waste down to the waste collector box and the bottom opener makes way by opening the bottom part of the pipe for the waste to fall into the waste collector box shown in Figure 3.2.

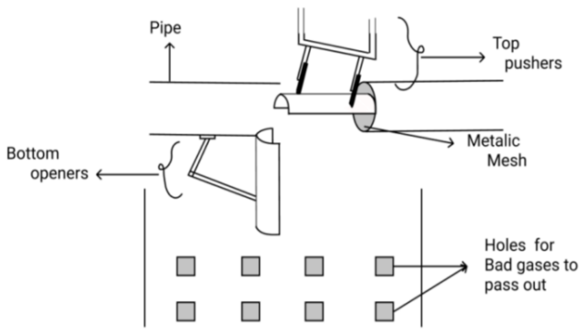

Figure 3.2: Open and close mechanism in collector box

Finally, all the waste that comes down from the pipe is collected into the waste collector box and then, that waste is converted into natural manure. With this it's possible to obtain natural manure and pure water at the same time. There are square holes present in the walls of waste container box which is used to get rid of bad stink and any waste water accidently fall into it. The main working mechanism of the purifier can be designed in such a way that the water in the solid waste is also collected and purified, this water flows back to the starting point or the purifier tube. As and when the waste gets collected in the waste collector box, there may be formation of bad smelly gases and in order to outlet such gas holes are made on the sides of the inner box, the water will also get out of these holes eventually. Then the water is squashed from the solid collected waste. The squashed water is then passed to a separate pressed water container and from there water is pumped to the start of the distillation tube with a proper back water pipe connectivity so that even the water in the solid waste will be purified. The bad smell produced by the collection of solid waste is passed through the pipe line that leads to the local drain so that smell can be let out to the local drain that are already present. The organic waste forms manure that can be used for agriculture since it is natural and chemical free. The chemical mixed water (from shampoo, soap, detergents) will have a separate pipe for purification and the organic waste can be treated separately to obtain natural manure.

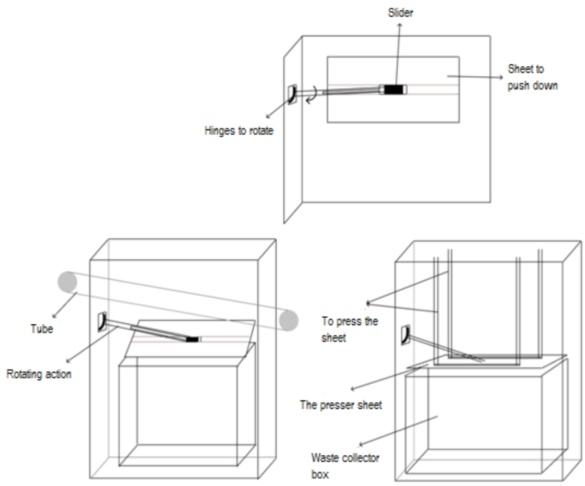

Figure 3.3: Working of Metallic Squashers

The squasher shown in Figure 3.3 is used to squeeze all water from the solid waste that is collected in the waste collector box. At first the metallic sheet will be at the side wall of the box, then at the hinges a rotating arm which is connected to the sheet is rotated and the sheet will be brought to its position inside the small box at top. The sheet will take its position from the tube side to the exact top of the inner box to press all the waste in the waste collector box. But the sheet alone cannot press all the solid waste, in order to support the sheet to press the waste down there are rods which press the sheets. The rods that press the sheet will be connected at the top of the main box then will extend down in order to press down and help the sheet to press the solid waste and squeeze all the water content out from the solid waste.

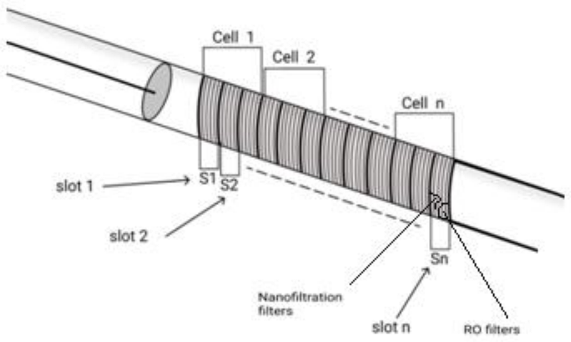

Figure 3.4: Custom design of nanofiltration and RO filters

The use of these filters is usually done in water treatment plants for recycling and reusing it, whereas the same kind of filters are being used in this work as well but in a different design as there are custom designed cells, cells slots contain the arrangement of nanofiltration and RO filters shown in the Figure 3.4. A group of few slots form a single cell, these cells are removable and replaceable. When the slots get dirty or old, they can be cleaned or replaced respectively. All slots in all cells will not be used equally, so it is just need to rearrange them to get full usage from all the cells. The metallic mesh will be placed right next to the filters without any gap, all cells also will be arranged in the similar manner. The slots in the starting, experience a large amount waste purification than that of the slots at the last. This we can overcome by changing or servicing them eventually as they get dirty. A custom designed filters can be the combination of nanofiltration and RO filters that helps in better purification. The parallel arrangement of filters where nanofiltration filter comes first, then RO filters are placed so that the larger particles will be blocked by nanofiltration filter and very small particles will be blocked by RO filters. As per the strength of the filters in this design should be monitored and the durability and life time of the filters can be determined based on that data. As and when there is deposition of dirt on the filter they need to be cleaned and change the position of the cells.

4. TECHNICAL PROCESS

The Two - Phase distillation tube can be developed with Arduino uno which is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and anolog input/ output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of Pulse Width Modulation output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B Universal Serial Bus cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts and is similar to the Arduino Nano and Leonardo [6]. This work is IoT based as every physical action is linked with various sensors, some of the sensors are Ir-sensor, Colour sensor, Position sensor, Gyroscope, UV-sensor, Depth sensor, Water sensor, Water level indicator, Presser sensor and Motion sensors just to mention a few. The software tool used to program is Arduino IDE which is a development environment, it is also a cross platform application. It is used to write code and upload it into the Arduino board. The heart of the project is the filters, where nanofiltration removes most organic molecules, nearly all viruses, most of the natural organic matter and a range of salts. Nanofiltration removes divalent ions, which make water hard, so nanofiltration is often used to soften hard water. Reverse osmosis filters; as water passes through a reverse osmosis filter, it is essentially pure water. In addition to removing all organic molecules and viruses, reverse osmosis also removes most minerals that are present in the water. There is custom made pushers and pullers which act as the main mechanisms of all the physical actions, these are the custom designed metallic rods that are controlled by the micro-controller, these actions are executed with precise positioning and correct timing. They move up and down accordingly to with the help of joints and electronic drivers. The pipes used are the regular polyvinyl chloride (pvc) pipes that are usually in local water transportation. The size depends on the amount of water flowing through the pipes. Manure is obtained by the organic waste and that can be used for agriculture since it is natural and chemical free. The chemical mixed water will have a separate pipe for purification and the organic waste can be treated separately to obtain natural manure.

5. EXPECTED RESULTS

The expected result is mainly to obtain purified water using Two-phase distillation tube, there are several filters that purifies when the waste water passes through it. The waste sewage water contains solid suspended particles which should be removed by the metallic mesh at the starting of the filters. The process of separation of those solid particles are gone by a custom mechanism that pushes all such solid waste to a box. The sensors come into action and interact with the microprocessor about the next task to be carried out and according to the signals of the sensors the separation of waste is done. By end of the filtering process clean water is obtained that can be used for multiple purposes.

CONCLUSION

The proposed work is to treat water and obtain clean water from the grey waste water, this project may be applicable from small home to large apartments and industries since it is a very efficient and smart method to use Two-phase distillation tube. Groundwater level depletion has been a major concern & is also a serious threat to the environment, adopting mechanisms for reusable water can solve water scarcity and also reduce our dependency on groundwater. Through this, in the longer run, we can increase the groundwater level for the future generation. Experimental set up, implementation and proper installation may certainly help the water treatment method harmless to the nature and can also protect mother nature.

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