Active utilization of grey water in residential buildings using IOT

A review paper on recycling and natural distillation

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Abstract: In recent days, automation and communication has made a rapid change in our living society. As a result of it, urbanization of semi urban and rural areas is taking place in a faster rate. There is steady rise of residential population growing in and around the cities and towns. The residential buildings are vastly increasing to occupy approaching population, as there is ample number of opportunities in cities. The land utilization plays a major role in this high-speed urbanization. Currently, we could find a large group of land promoters building a number of apartments in a single community area with numerous flats occupying a huge sector of population. Now, the population in such community area demands a good source of domestic resources such as water and power. Here, water plays a major stock holder's part. It's really a challenging scenario to handle sewage generated from these residential buildings. Sewage treatment plants are installed by the corporation boards to treat, recycle and reuse the water. In few cases, the sewage is let out into water bodies available in nearby areas and most of them left untreated. The paper proposes an idea to treat, recycle and reuse the domestic sewage within the residential campus and dispose the untreated sewage to common disposal channels in the cities. The paper pitches the usage of domestic sewage commonly known as grey water to utilizable water for non human consumption like gardening, flushing toilets and other demand dependent uses.

IndexTerms **– Grey water, Sewage Treatment, plant filtration, sensors.**

I. INTRODUCTION

Generally, wastewater is classified as grey water and black water. Grey water is a domestic wastewater usually produced during domestic works such as bathing, laundry and washing dishes. Wastewater composed of 55-75% of residential wastes in water. Grey water is different from black water in both composition and amount of its biological and chemical pollutants (feces water to noxious chemicals). Grey water is commonly gathered from residential sectors, commercial centers and institutional sectors. The appearance in cloudy nature and its presence neither fresh (white water from ground water or portable one) nor hardly polluted (black water) makes the water termed grey in color. Exactly to say, water discharged from residential buildings except toilet wastes is grey water. Even though, the grey water contains food particles, hair, grease and many other impurities, it could still fit for reuse.

Reuse of grey water fulfills two points: First and foremost thing is, it decreases the quantity of freshwater necessary for household works and decreases the quantity of wastewater collected in sewage tanks or septic tank systems. Naturally, Grey water contains nutrient that may turn to be a valuable fertilizer, if used. Mostly, it is treated as sewage and released into ponds, lakes and rivers, making it to be a pollutant.

The reuse of greywater for gardening rejoins the water with natural water cycle in urban residential areas. The urban population can use it for either backyard gardening or nurture ornamental plants. The grey water must be treated with natural or artificial filtration process and it must meet the quality standards and if it handled improperly, it may be a potential treat to environment. For most of the apartment residents, the space for treatment of grey water seems to be a nightmare.

The importance of grey water shows high value during water shortage and in efficiency of government to handle sewage water. Due to presence of particles in grey water its biological and chemical properties must be taken into consideration as it may be suggested that grey water could contain some properties which could cause dilapidation to soil and to plants. The grey water from dish washer and kitchen sink can carry large quantity of fats, caustic additives and organic materials in high ratios that are not immediately cracked down by organisms in soil. Detergents and Soaps are elements in grey water that would affect the plants adversely. To handle it, grey water must be processed through natural filtration process to make it safer to use. The quality need to be checked and ensured before use of recycled grey water. The filters should be made in such a way that it can be handled by general public and it must be flexible to spacing. Example: In apartment roof floors, Garden floors, Parking spaces.

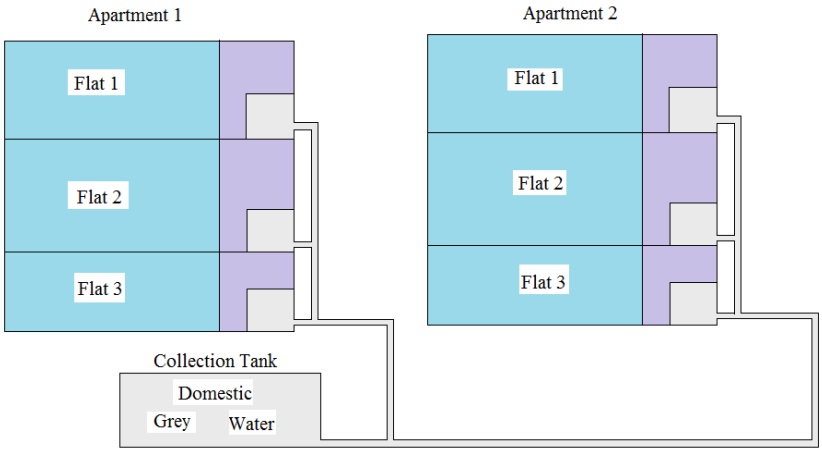

Figure 1.1 – Model of apartment buildings with common grey water system

II. LITERATURE SURVEY

Vandana Singh et al., (2018) excavate clearly in their paper about the grey water and black water and their filtration process through each stages of treatment technologies. The paper gives idea on complete filtration techniques. Martina Rysulova et al., (2017) proposed a new way of biofilter for greywater known as green wall. It treats the grey water through vegetated wall that uses grey water at stage on stage. The idea is simple and does it yourself methodology which will support gardening of ornamental plants in high storey apartments. Abeer Albalawneh et al., (2015) in their paper figure out the characteristics of composition of grey water and discuss about various filtration techniques like physical, chemical and biological treatment.

Narges Shamabadi et al., (2015) in their paper recommend grey water treatment system that uses trickling filters composed with suspended plastic medium. The method suggests a mechanism in which the waste matter (if existing) gets removed by a mesh composite of 1cm thickness. Then, the grey water gets collected in a buried tank and the outlet water is pushed through pump to the trickling filter and the water gets back to the tank counting thrice the process. The water from trickling filter is led to the settling tank, where the sludge produced as end result gets settled down. Finally, the water is passed to chlorination system to sterilize it.

K.A.Vakil et al., (2014) presents a new concept of grey water treatment through electrochemical reactor that runs with a supply voltage of 12V Dc. Erwin Nolde (1999) states the reuse of greywater in a multi storey building with natural treatment using sand filter with reed bed and biological treatment using membrane filtration with UV disinfection setup. The paper gives independency to select the filtration process based on economical perspective. Sara Moslemi Zadeh et al., (2013) in their paper suggest that Grey water (GW) recycling helps urban water management system to use it for non-portable activities like urinal and toilet flushing. This strategy helps to alleviate the risk of water demand. The paper initiates a novel method of cross connection system that accumulates Grey Water from residential buildings and recycles it for flushing urinal/toilet in both residential and commercial buildings.

Sara Finley et al., (2009) represented in their paper about the benefits and treats associated with reuse of domestic grey water that serves the need of vegetable garden irrigation. Further, the paper discusses about untreated (only settled) and treated (settling and slow sand filtration) grey-water gathered from residential families to irrigate vegetable gardens. Pinto et al.,(2010) discuss in the paper about glass house experiment that addresses the effect of grey water for cultivation of silver beet roots and soil properties.

III. THE PROPOSAL

Construction of a valuable water management system for utilization of grey and black water in housing units, apartments or flats is a price worthy one. Our proposed model is to show, how this could be achieved through the idea of automating day-to-day water management system.

A. Sources of Grey water:

India Water portal has released a strategy statement that cities in India produce approximately 40,000 million liters of sewage per day. Closely, 80% of the sewage produced in India runs unclean into its ponds, rivers and lakes, polluting the water sources that are yet to be used. Untreated sewage from Delhi- Mumbai cities running into water bodies have almost came close to around 24,000 million liters per day from 12,000 million liters per day in tier I and tier II. An alarming fact is that 302 tier I and II towns in India don't even poses sewage treatment plants.

The grey water is classified according to its source such as

- Grey water from Kitchen - The water might contain organic stuffs from food sources, soap and detergents from utensil washing and the main contaminants being carbohydrates, proteins, oil and grease, detergents and other suspended and dissolved compounds.

- Grey water from Personal works (Bathroom waste and Washing clothes) - The water might contain oil, grease, odor, soaps, hair, bacteria, foam, bleach and suspended solids.

The sources further, classifies grey water as

- Light Grey water – The water from bathroom basins (sinks), showers bath tubs and clothes washing machines. There is no necessary for treating these grey water and can be used directly within 24 hrs. However, quality check must be ensured to find the proportion of ingredients the water contains from the household works.

- Dark Grey water - All grey water from residential flats or apartments except the water that does not combines with wastewater from urinal or toilet. The water can be stored more than 24 hrs and the water must be treated through filtration process before usage.

B. Reuse Through Recycling

Although, greywater is not suitable for consumption by humans, it is a potential resource for gardening and acts as a water recycler in urban and semi urban areas. Grey water treatment is a low expensive operation comparing to water desalination. Grey water need to be analyzed with quantity of Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and total suspended solids (TSS). The filtration must be in multiform. As in standard filtration process, there is an inability to refine excess chemicals, minerals and salts through less expensive method. Chlorine along with disinfecting additives is mixed to the water to prevent it from disease spreading microorganisms. The proposed idea uses three filtration processes that include:

- **Slow Sand Filtration:**

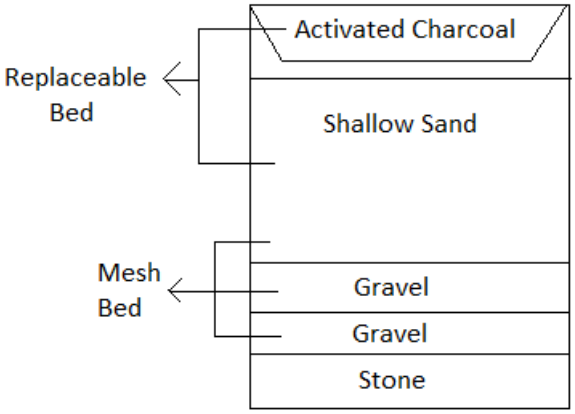

Figure 3.1 – Sand bed composition

The dark grey water is taken for filtration through slow sand filtration method. First level of filtration is through charcoal which reduces cloudiness, bacteria and organic levels—thus, decreasing the occurrence of byproducts that disinfects the finished water. Here, the handling of sludge is minimal due to charcoal bed. Then, the water is passed through sand bed filtration. The operation is feasible as the charcoal bed can be replaced weekly. The supervision is not a big task. The system uses gravel beds followed by stone bed and it can be constructed through locally available materials with least labor charge. The slow sand filter removes total organic carbon, pesticides and THM precursors effectively. The effectiveness of slow sand filters decreases as temperature decreases because the biological activity declines with decrease in temperature.

- **Reed bed Technology:**

Reed beds are engineered systems that offer water management by means of a non-active and organically-mediated process. These non-active wetlands for wastewater management is a good option for recycling of water as it provides a far-fetched significance by means of twofold utilization of the given area as beautiful, greenish and chill regions that make easy the eco-friendly and sustainable water management techniques.

Reed beds seem to be the most important progress in water and sludge management system because the activated sludge method was first used before a century. The activated sludge method symbolizes the only significant advancement in wastewater management from 1914. During that period, this method was a burst through in people's well being and became the standard wastewater treatment across the earth. Major advancement had been done in the domain of water management in Europe and U.S. Thereafter, many eco-friendly and sustainable techniques arises like wide-ranging wetland systems to manage household waste water, sludge treatment, polluted groundwater, leachate and industrially processed water.

3 important Reed bed steps that makes possible sustainable water treatment:

1. Natural ventilation of the primal surface to progress the aerobic and anaerobic activities in polluted water source.
2. The growth of microbial biofilms in the primal surface and rooted areas of plants.
3. The rows of reeds afford a good looking green region and make a governing role in preserving independent drainage through the structure and avoid blockage.

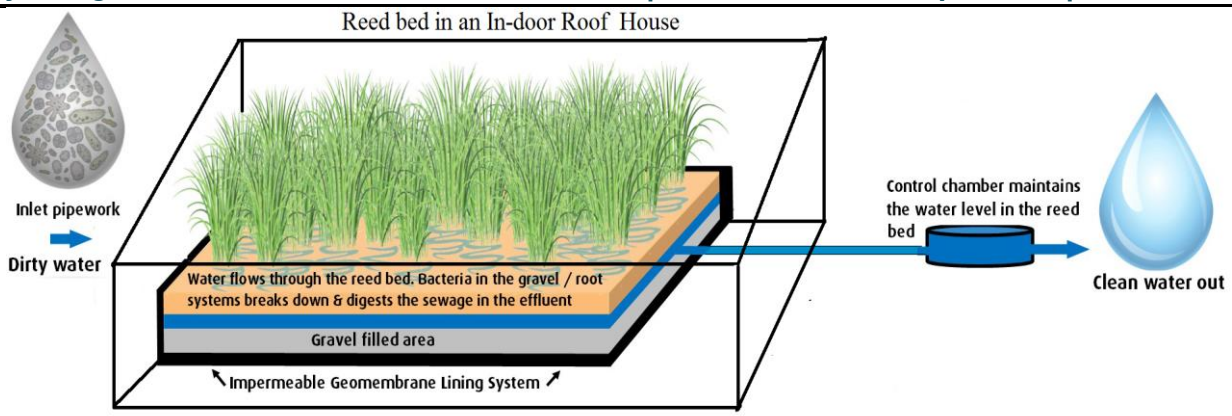

Figure 3.2 – Reed bed in-door roofing filtration system

In Reed bed method, the wastewater reed cells depend on organic, eco-friendly treatment processes to get rid of color, muddy and suspended organic matter from the water. They need no chemical dosage but can convert untreated waste water into one that fit for reuse and set free into lands. These self assisting systems will function with no drop in action, with no unearthing or rooting of plants required. Reed bed systems are aesthetically pleasing besides they can well incorporated in the open-air atmosphere and permit twice utilization of space.

- **Flow-Down Systems:**

Multi-stage reed bed systems are integrated with multiple stages of vertical flow of waste water. The system works on the principle of saturate and discharge process where a single bed saturates completely by 12 hours while the next one discharges and the cycle continues. The ideology behind the system is that the effluent saturates out from the gravel bed, air is sucked in and assists to form an aerobic bacterial colony in the gravel bed surface to digest out the pollutant. These systems predominantly needs electric motor pumps, timing circuits and control panels as the pollutant is transferred from one reed to other for every 12 hours.

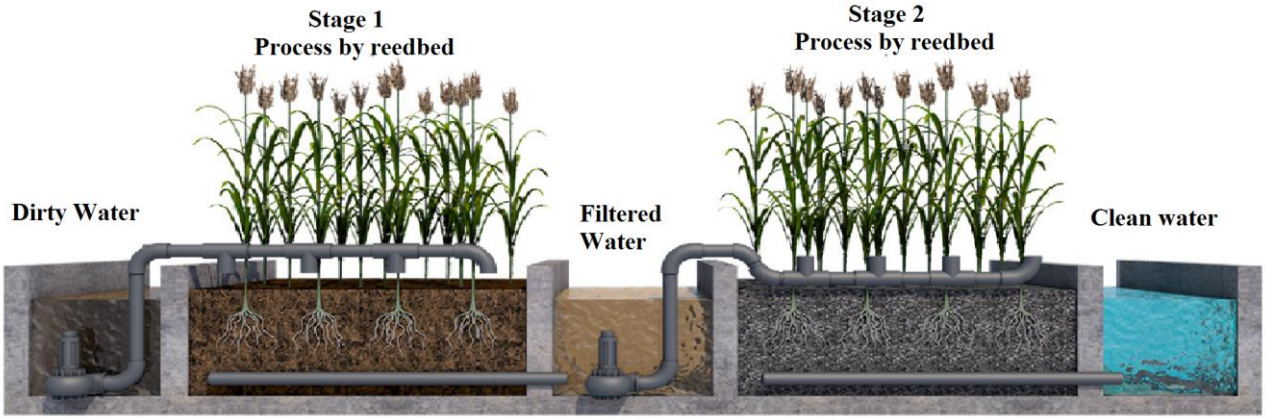

Figure 3.3 – Flow down reed bed filtration system

➢ **Distillation by Natural Materials:**

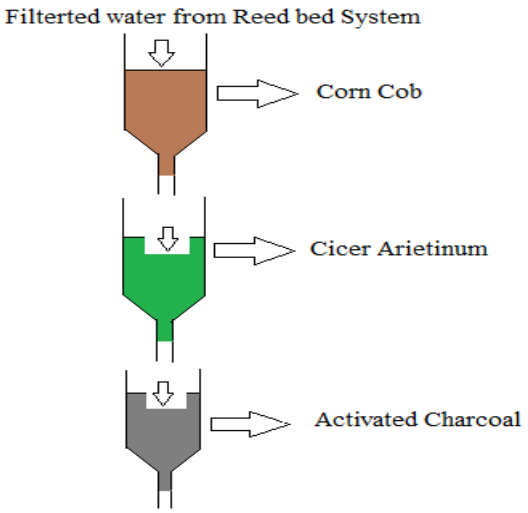

Figure 3.4 – Distillation model through multi-filtration process

Grey water treatment eradicates large contaminants from water like hair, dirt and grasses. One difficulty with standard filters is that they are unable to refine excess salts, chemicals and minerals that may pollute the water. Chlorine and disinfecting additives can be added to the water; however it would be ideal to minimize the addition of artificial chemicals in grey water treatment for agricultural use.

Natural fibrous components like activated Charcoal powder, Cicer arietinum and crushed corn cob have the ability to cleanse grey water. The corn cobs have the potential to filter chlorine, nitrates, and calcium & magnesium concentrates; but, iron content (0.3ppm) stay behind will be destructive for consumption and cultivation.

When the level of iron is around 0.1ppm, it may result in plant discoloration and can even turn toxic for plant tissue. The expected pH valve for irrigation purpose ranges from 5.0-7.0. The filtration of water through seeds diminish copper, nitrate and iron levels to 0 ppm, the pH turns quite acidic and the hardness of water increased to 100 ppm to 250ppm. Even though, this mineral concentration is not perfect for human consumption, the rich content becomes beneficiary for healthy plant growth (until, it not exceeds 250 ppm). The filtered water through charcoal yield familiar results as that of seeds: tested properties of chemical found to be 0 ppm, pH value reached 5.0 and hardness rose to 250 ppm. Active charcoal and seeds performed as best filtering agent for grey water.

IV. WORKING PRINCIPLE

The apartment grey water gets collected in a common space in the residential community making the collection process flexible. The apartment water tank is constructed as a ground water tank for the storage of grey water with ventilation and air circulation funnels to reduce odor of the water. The storage tank can be either removable syntax tanks for the apartments. As space is a constrain for many buildings. The filtration process starts with the first method of slow sand filtration and it is exposed to air with sand bed. Here, the sludge from the grey water gets settled at the top of the shallow sand bed. The bed can be replaced with periodical sand beds when, the sludge gets accumulated above the handling capacity of the bed. It's a slow filtration process. It takes over 12hrs to get settled down. Then, the filtered water is accumulated in another tank for further filtration process. After first filtration process, the quality check takes place. Now, the water is free from soap, detergent water and tiny sediment particles.

Then, the controller governed by internet of things, measures the level of the water periodically and the filtration process further extends to next level of filtration that is reed bed filtration through aquatic plants. Here, the flow down system in reed bed technology helps the grey water to dissolve biodegradable and potentially higher end solvents to break down in to digestible one. The grey water from reed bed technology loses its strength of contamination. Now, the grey water has minerals like copper, nitrate, iron to be removed for consumption and utilization.

Finally, the grey water passes through quality check process and reaches third filtration segment known as natural distillation through agricultural waste like corn, seed and plants waste. Here, it's through funnel filtration. The water strength needs to be accounted to term it as acidic or alkaline. The PH level of the water and minerals are removed through corncob, cicer arietinum and charcoal funnel distillation process respectively.

At the end, before utilization, filtered grey water is checked with all quality check parameters. If the water collected is excess, it can be used for gardening or watering ornamental plants. When the water collected is medium, it can be used for flushing toilets, car wash and non-contact use for home. If the water is low or below par to hold, it can be used for flushing toilets and dispersal of sewage waste from apartments. Since, it is a long term process, it can be implemented as a community based welfare project. The apartments with minimum 30 flats can be combined together to bring out a utilization plan for their grey water accumulation.

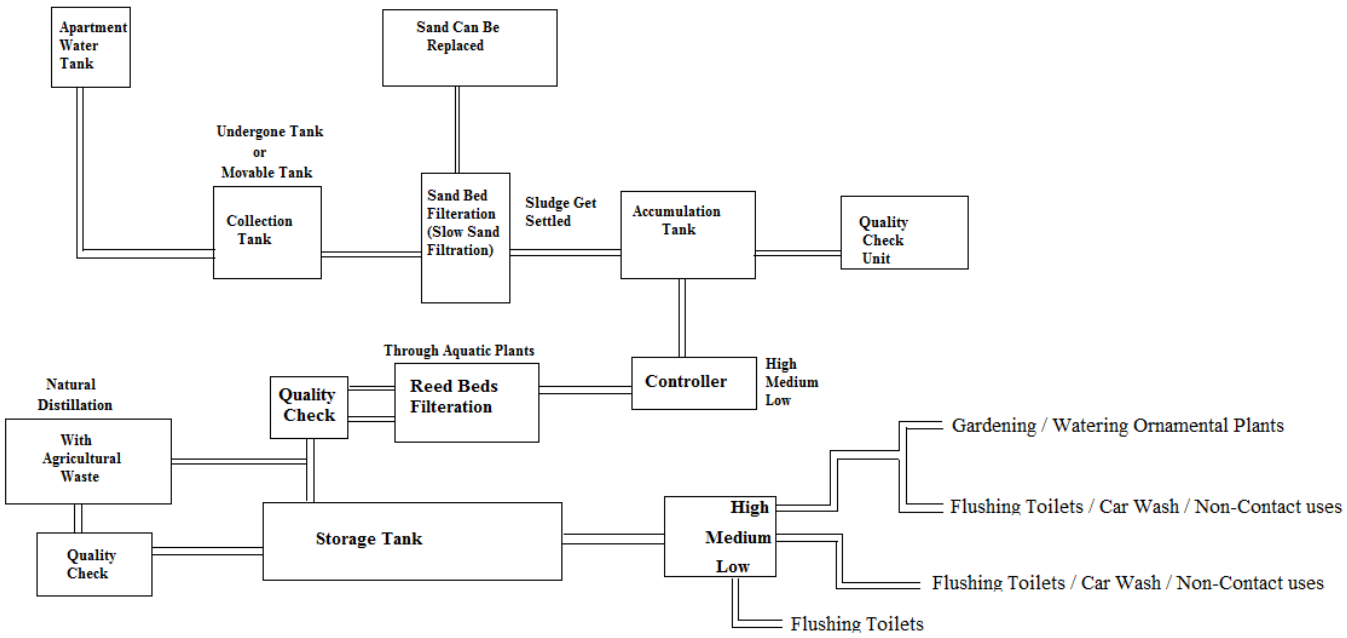

Figure 4.1 – Working block diagram of grey water recycling and usage

V. RESULTS AND DISCUSSION

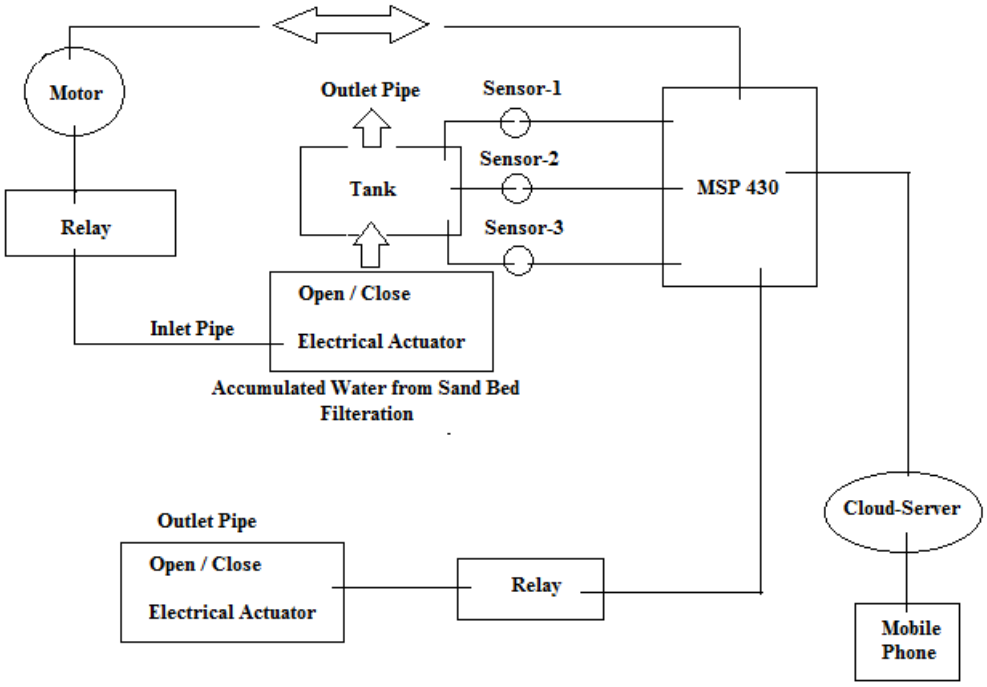

Figure 5.1 – Block diagram of internal circuit for controller

When the accumulation tank gets filled up, the sensors S1, S2, S3 turns high (111). The signal high is processed by MSP 430 and it sends an interrupt to motor to stop its function. The Motor has a bidirectional operation. It communicates with arduino MSP 430 to turn up the electrical actuator. The electric actuator is connected to inlet pipe of accumulation tank through relay. If the sensor valve turns any combination other than high (111), the motor runs to fill up the accumulation tank. The outlet pipe of accumulation tank is attached with electric actuator and connected with MSP 430 to open up the pipe next filtration process. The condition to fill the accumulation tank and empty it can be changed according to demand of end user. Hence, the entire working setup is connected to cloud server to be accessed by end users of respective apartments through their mobile communication.

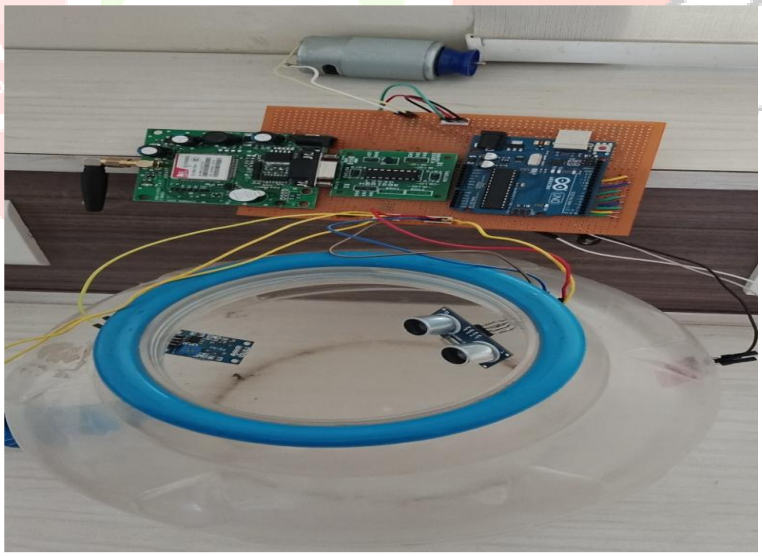

Figure 5.2 – Prototype of accumulation tank with IOT

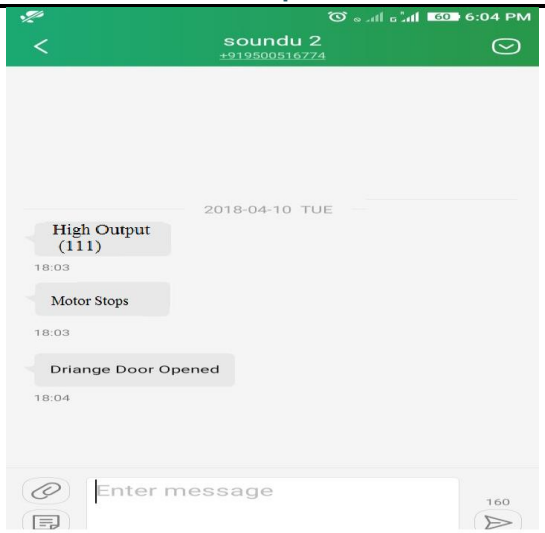

Figure 5.3 – Output message of controller

VI. ACKNOWLEDGMENT

We thank India Water Portal to support the paper with data and present day scenario in issues on grey water handling by metropolitan cities in India. A strong initialization to recycle water was suggested by the site to common public.

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