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Comparative Analysis of Design of Water Filter for Rural Areas

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Abstract *- Over 1.34 billion people, including 0.51 billion children's below six die every year because of infected drinking water. According to United Nations Children's Fund (UNICEF) and the World Health Organization (WHO) One in eight people worldwide lack ingress to safe, clean clear potable drinking water, and maximum people had no choice but to drink the contaminated water with potentially life threatening bacteria and viruses. In poor developing countries people like India, obtain up to 5 gallon (Appox.19-20 liter) of safe, clean water each day. In ancient ages of human civilization boiling of water over a wood fire is one of commonly practices clean method for water purification, but it is still hazards in poor ventilated kitchen This paper is an attempt to inspect, examine and review the published research papers that have been carried out by various investigators so far with various low cost water treatment methods suitable in rural areas such as developing low cost water filters by using different filter media and different filter layers. This low cost water filter treatment is a sustainable tool option for rural areas.*

Key words *- Water, Water filter, Filter Medias & Filter layers.*

I. INTRODUCTION

Water is the main constituent in our body. Human body composed mainly of water on average about 70%. Human being brain, for example, is about 85% water, liver 90%, blood 83% and even the bones 35%. Therefore, consuming enough water in our daily life is a must to stay hydrated and healthy. According to the World Health Organization (WHO), over 1.34 billion people lack access to safe drinking water supplies. This has led to extensive universal microbial contamination of drinking water. Water-associated with contagious diseases claim up to 3.3 million lives each year, approximately 6.2% of all deaths globally. The load of diseases from inadequate water, sanitation, and hygiene totals 1.81 million deaths and the loss of greater than 76 million healthy lives. It is well accepted that investments in safe drinking water and improved sanitation show a close correspondence with advancement in human health and economic productivity. Each person needs 25 to 50 liters of water free of harmful chemical and microbial contaminants each day for drinking, cooking and maintain hygiene [6].

Tap water is the major supply of our drinking water but it is actually not impregnable to consume it regularly as it contains high level of chlorine, leads, fine microscopic which causes cloudiness, bad taste and smell, and also bacteria. The used water is being treated to be reused which means large amount of chlorine is used in order to cleanse it. Tap water that is devour every day is not safe as it contains high level of chlorine, leads, fine microscopic which causes haziness, bad taste and smell, and also micro bacteria. However, this matter can be unexpectedly by first, filter the water and after that boil it.

Different types of portable water filters available, with varying degrees of effectiveness, can be used together with physical and chemical purification. Portable water filters are usually small, portable and light (1.0-1.5 kg) and usually filter water by working a mechanical hand pumps, although some use a siphon drip system to force water through while others are built right into water bottles.

A water filter is a setup which removes impurities from water by means of a fine physical barrier, a chemical process and biological process. Filtration controls entirely on particle or droplet size (and, to some extent, shape), such that particles below a certain size will pass through the hurdle, while larger particles are retained on or in the barrier for later removal [7]. There are a number of tap water filtration systems available in the market, but not all of them are of good quality.

The technology is highly improved and the water produced by these filters is much safer and cleaner than ever before. However, recently it is hard to find a portable water filter where consumers can carry it anywhere and used it for more than one purpose. Hence, we have come out with a solution to design a portable water filter with extra feature, which is the heating element to boil the water. In terms of scientific point of view boiling would be able to kill all the germs and microorganism in the tap water. There are a few aspects that needed to be considered in the design process which are economical, convenient and user friendly in rural areas.

II. DIFFERENT FILTER LAYERS

A. Gravels: Filter Gravel is an extremely effective filter media because of its ability to hold back precipitates containing impurities present in water. It removes coarser particles present in water. Filter sand size, angularity and hardness are the important filter sand characteristics to ensure proper filtering. Gravel products meet or exceed the NSF/ANSI Standard 61 for Drinking Water System Components, as well as AWWA Standard B100-01.

Physical Specifications of Gravel:
Effective Sizes: 1/8" - 2 1/2"
Uniform Coefficient: 1.2 - 1.7
Specific Gravity: 2.70
Moh's Hardness: 6
Density: 100 lbs per cubic foot. [8]

***B. Silica Sand*:** Filter sand is an extremely effective filter media because of its ability to hold back precipitates containing impurities. It is mostly found near bed of river. It removes fine particles and some extent of turbidity from water. It is more effective than gravels for removing impurities present in water. Filter sand size, angularity and hardness are the important filter sand characteristics to ensure proper filtering. Products meet or exceed the NSF/ANSI Standard 61 for Drinking Water System Components, as well as AWWA Standard B100-01.

Physical Specifications of Silica Sand:
Effective Sizes: .20mm - 2.5mm
Uniform Coefficient: 1.3 - 1.7
Specific Gravity: 2.67
Moh's Hardness: 7
Density: 105 - 115 lbs per cubic foot [8]

C. Anthracite: Anthracite filter media is produced from the highest quality anthracite available to ensure the physical characteristics of hardness, durability and performance. Anthracite typically produces uniform improvements in turbidity removal because, in part, to more efficient solids loading which is responsible for turbidity. Low evenly coefficient media also produces smaller changes in effluent turbidity during periods of peak influent turbidity. Anthracite filter meet or exceed the NSF/ANSI Standard 61 for Drinking Water System Components, as well as AWWA Standard B100-01.

Physical Specifications of Anthracite:
Effective Sizes: 0. 60mm - 1.6mm
Uniform Coefficient: 1.3 - 1.7
Specific Gravity: 1.3
Moh's Hardness: 3
Density: 50 lbs per cubic foot
Moisture: <2.0% [8]

D. Garnet: Garnet is an ideal water filter media. Garnet is a chemically inert and non-metallic mineral, which is commonly found in the natural environment. Garnet is well known for its hardness, stiffness, rigidity, denseness and durability. It has a high specific gravity as well as its chemical and abrasive resistance makes garnet an ideal filter media. This product exists in both large sizes conducive to support beds, and in smaller sizes for cap beds and is dense enough to allow faster back flushing. Products meet or exceed the NSF/ANSI Standard 61 for Drinking Water System Components, as well as AWWA Standard B100-01.

Physical Specifications of Garnet:
Effective Sizes: 0.20mm - 2.0mm
Uniform Coefficient: <1.6
Specific Gravity: >4.0
Density: 120 - 140 lbs per cubic foot [8]

E. Greensand Plus: It is a purple-gray filter media used for removing soluble iron (Fe), manganese (Mn), hydrogen sulfide (H_2S), arsenic (As) and radium (Ra) from well water supplies. The substrate media has a manganese dioxide (MnO_2) coated surface that acts as a catalyst in the oxidation- reduction reaction of iron (Fe) and manganese (Mn). The difference between Greensand Plus and manganese greensand is in the substrate that forms the core of the media and the method by which the manganese dioxide coating is attached to that substrate. It has a silica sand core and the coating is fused to it while manganese greensand has a glauconitic core and the coating is ionically bound to it. The silica sand core of Greensand Plus allows it to better withstand operating conditions in waters that are low in silica, Total dissolve solids (TDS) as well as hardness. Also, it can withstand higher operational temperatures and higher differential pressures than can manganese greensand. The higher differential pressure may permit for a longer run length, but, if nothing else, allows for more operational margin. Along with the added benefits comes the fact that Greensand Plus is an accurate replacement for manganese greensand.

Physical Specifications of Greensand Plus:
Manganese Greensand Form: Black nodular granules of manganese-coated natural greensand
Apparent Density: 85 lb./cu. ft.
Shipping Weight: 89 lb./cu. ft.
Screen Grading: 18 x 60 mesh
Effective Size: 0.30-0.35 mm.
Uniformity Coefficient: Less than 1.6
Specific Gravity: Approx. 2.4 [8]

F. Mix of all filter layers. (Well pack): This material is of even and uniform grain shapes and grain size distributions produce efficient filtration bed operation for removal and discard of contaminants in both potable water and wastewater. Clean and chemically inert, these silica products will not degrade or react when it comes in contact with acids, contaminants, volatile organics or solvents due to its low acid solubility and dissolve properties. Due to this materials sub-angular shape and uniform size, they are ideal for use as packing material in deep-water wells to increase yield and produce from the aquifer by expanding the porous and pervious zone around the well screen and preventing the infiltration of fine particles from the formation. The uniformity and low acid solubility also minimizes and reduces the material lost during well development. The sub-angular shape aids hydraulic conductivity by reducing drawdown and improving and upgrading the yield of filter. [8]

III. DIFFERENT FILTER MEDIAS

1. ***Charcoal:*** Active charcoal carbon filters are most effective at removing chlorine, sediment, volatile organic compounds (VOCs), taste and odour from contaminated water. This is the most widely used media. It is used to remove bacteriological impurities present in water but they are not effective at removing minerals, salts, and dissolved inorganic compounds. Typical particle sizes of impurity that can be removed by carbon filters range from 0.5 to 50 micro-metres. The particle size will be used as part of the filter description. The efficacy of a carbon filter is also based upon the flow rate regulation. When the water is allowed to flow through the filter at a slower rate, the contaminants are exposed to the filter media for a longer amount of time.[11]
2. ***Rice Husk:*** As it is easily available in rural areas so widely used. It removes suspended impurities. Obiora-Okafo Ifeoma A. et al. in (2013) studied the removal of fluoride from groundwater by aluminum hydroxide coated Rice husk ash [9]. Activated aluminum hydroxide has been used for activating the RHA surface which forms a complex with fluoride ion in water and accelerates the process of removal.RHA was obtained by controlled burning of dry and crushed rice husk and treating with hydrochloric acid before activation.[5],[6]
3. ***Alum:*** The most cheaply available media is Alum. It removes mostly suspended impurities by floc formation. Aluminium sulphate or Alum is used as a coagulant and flocculant to remove unwanted colour and turbidity from water supplies. It has been used since ancient times for this purpose and its use together with filtration is standard practice in conventional water treatment processes around the world. After performing its role, the Alum is filtered from the water but a small fraction dissolves and is not removed.[2]
4. ***Moringaoleifera:*** *Moringaoleifera* is most popularly known as drumsticks. It removes suspended impurities and bacteriological impurities to some extent.[1]

IV. COMPRATIVE ANALYSIS OF DIFFRENT DESIGN OF WATER FILTERS

Chauhan Shweta et.al.(2015), reported that the application of plant extracts as a filter media of Moringaoleifera, Arachishypogaea (peanuts), Vignaunguiculata (cowpeas), Vignamungo (urad) and Zea mays (corn) are showed the significant decreased, up to 92% in the reduction of microbial counts. During their work, examination of treated and untreated sample water for heavy metals and microbial counts was analysed and tested.

Their results of treatment with these natural extracts also helped in the coagulation of the heavy metals like lead, copper, nickel etc. present in the treated water samples. They examined that seeds and leaves extracts were also more effective in clearing and in sedimentation of suspended organic and inorganic matter present in water samples. [1]

S. Jayadev et.al. (1990), designed a filter of low cost adsorption filter media for removal of bacteria and turbidity from water. They used alum-treated Giridih bituminous coal (alum-GBC) and ferric hydroxide-impregnated lignite (Fe-lignite) ranked highest among the coal/lignite based media. The four media, viz., alum-GBC, alum-GBC-Ag, Fe-lignite, and Fe-lignite-Ag were subjected to batch sorption/inactivation study by contacting the media (0.2-1.0%) together with the data on enteric(polio and rota) virus removal by alum-treated Giridih bituminous coal, suggest potential usefulness of silver-incorporated alum-treated bituminous coal as a medium for a domestic water filter in rural areas of developing countries.[2]

Henry Michael et .al. (2013), designed a low cost ceramic water filter of ceramic filters which is work by using porous materials which allow water to flow through while restricting the passage of potentially harmful microbes. They reviewed that over a thousand years ago, when porous clay and sandstone were used to filter water in Sri Lanka. The pores are large enough to allow the passage of water but not the microbes that cause water-borne disease. They stated that modern filters are made by mixing clay with sawdust, rice husks, or other flammable organic materials. After being shaped into a filter with a press, they are fired in a kiln. The organic material burns out, leaving small pores of about one micron in size, which can filter out the majority of harmful microbes. This filters are also remove particulates and protozoans (which are larger than bacteria). Further, with the addition of colloidal silver (a broad-spectrum antimicrobial) the filters have100% effectiveness in tests for removal of E-coli. [3]

Mohanad El-Harbawi et.al.(2010), analysed that filter media as like activated carbon, silica sand, zeolite, bio ball, and mineral sand and they gives the various taste required for pure water. They design the cylindrical hollow filter cartridge is having a combination of filter pads consists five layers; activated carbon, silica sand, zeolite, bio-ball, and mineral sand. [4]

VCS Prasad (2002), studied the Rice-husk ash (RHA) as filter media for domestic filtration in rural homes. He was demonstrated the idea of a filter element trapping nearly 98 to 99% bacteria and turbidity with acceptable filtration rates when fabricated as single unit. [5]

Obiora-Okafo Ifeoma A. and Onukwuli O.D (2013) reported on the power of granular activated carbon made from agricultural waste (sawdust) for the removal of Total Dissolved Solid Particles (TDSP) in wastewater from a brewery industry. They found that the agricultural waste activated carbon in acid was found to be efficient and cheap viable adsorbent for TDSP adsorption. They used Rice-husk-ash as the bottom material for developing novel ideal formation to tackle with the challenge of purifying drinking water in rural areas in India. They reported that rice husk ash cast in a matrix of cement and pebbles can be formed into a filter bed which can trap up to 95% of turbidity and bacteria present in water. Another research includes embedding silver nano-particles within the rice husk ash matrix to create a bactericidal filtration bed which has now been commercialized in India as a low cost filter for household water purifier. Also, rice husk Ash has been rapidly used as an effective filter setup to assist filtration of difficult to filter solid-liquid systems such as colloids, fine, highly compactable particular solids, or hard to be deliquored materials. Current researches on Rice-husk-ash showed very good adsorption properties of it regarding colour, odour, COD, BOD, and iron, copper, arsenic removal in some types water and wastewater applications. [10]

Pankaj Singh et al (2014) summarised the report on Fly ash which is used as adsorbent for the efficient treatment of domestic waste water. They concluded that fly ash is a better option for the treatment of domestic waste water treatment and presented that the absolute dosage and duration for the treatment of domestic wash water waste is 40g/L and 6 hours. They observed that considerable reduction in the TSS, BOD, Soap content and pH has been seen in the treated water. [11]

V. CONCLUSION

By reviewing and studying various filters, filter media and filter layers we conclude that such filters with filter media and different filter layers can use completely in Rural Areas, which is very cheap and easily available in their areas. As above mentioned that about approximately 1.34 billion people still lacks access to safe water, so use such filter media which are easily available, economic, easy to use can treated water for drinking purpose in rural areas.

Based on the different filters, filter media and filter layers the purification of water, and maintaining the quality of water and comparative studies on various papers we can conclude that,

- *The filter media prepare by Shweta Chauhan, by using various plant extracts significantly decrease TBC up to 90% also 95% of Heavy Metals were removed from treated samples. According to such plant extracts filter media, reduce rate of filtration as well as controls the E-coli bacteria.*

- *The filter designed by S. Jayadev, as low cost filter by use of different types of Alums which can reduce the various hazardous bacteria which is responsible for human health. As he suggested mainly the Alum-GBC which can helpful to reduce the rate of purification for the bacteria.*
- *The filter designed by Michael Henry, as he used the filter media i.e. Ceramic, the ceramics are good porous material so it can reduce the harmful microbes from water due to which rate of further treatment can be decreases.*
- *The analysis according to Mohamad E. L. Harbau, as he used universal filter media, he studied first the properties of filter media and then arrange it in effective manner so can control each properties of water.*

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