Review Paper Renovation of Wastewater to Utilizable Energy

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Abstract— The need for alternate eco-friendly fuel is increasing rapidly with the depletion of non-renewable energy resources. Simultaneously, Management of waste water is being a big deal for government. This is mainly due to rapid urbanization and over population. Several disposal methods have been established and functioning till date. Increasing population leads to increment of the quantity of wastes which finally leads to dump of sewage results in production of diseases. An alternative method for disposal of sewage waste could be generation of renewable energy which is much essential today to compensate the insufficient energy. Here is a simple approach to treat the waste water and converting it into electricity where solar panels are one of the sources used for energy production and prevents the increment of household waste water. This process can either be followed by municipality at the destination of sewage collection or by a community level of people to fulfil their daily power needs. At community levels, a centralized collection and waste water treatment from households including toilets answers not only proper sanitation but if treated scientifically, yields renewable energy as well.

Key words: Wastewater, Recycling, Solar Dish Antenna, Energy Storage

I. Introduction

Increasing human activities are consuming the natural energy sources leading to the depletion of fossil fuels. The present-day energy scenario in India and around the globe is precarious. The need for alternative fuel [13], [3] has made us to initiate extensive research in identifying potential, cheap and renewable sources for energy production. The building of sustainable society will require reduction of dependency on fossil fuels and lowering the amount of pollution that is generated. Current methods to produce energy are not sustainable, and concerns about climate and global warming require developing new methods of energy production using renewable and carbon-neutral sources.

In India alone, no more than 30% of sewage generated by 377 million people flows through treatment plants. The rest is dumped in rivers, seas, lakes and wells, polluting three-fourths of the country's water bodies, according to analysis of various data sources. An estimated 62,000 million litres per day (MLD) sewage is generated in urban areas, while the treatment capacity across India is only 23,277 MLD, or 37% of sewage generated, according to data released by the government in December 2015. Further parsing of this data reveals that of 816 municipal sewage treatment plants (STPs) listed across India, 522 work. So, of 62,000 MLD, the listed capacity is 23,277 MLD but no more than 18,883 MLD of sewage is actually treated. That means 70% of sewage generated in urban India is not treated. While 79 STPs don't work, 145 are under construction and 70 are proposed, according to the Central Pollution Control Board's (CPCB) Inventorization of Sewage Treatment Plants report. India's towns and cities contaminate their own water, with no improvement over the years. Sewage generation in India from class-I cities (with a population more than 100,000) and class-II towns (population 50,000–100,000) is estimated at 38,255 MLD, of which only 11,787 MLD (30%) is treated, according to the Faecal Sludge Management report by Water Aid, a safe-water and sanitation advocacy, quoting a 2009 CPCB report.

The untreated sewage is dumped directly into water bodies, polluting three-fourth of India's surface water resources, the FSM report said. Up to 80% of water bodies could be polluted, the report said. Operation and maintenance of existing treatment capacity is below par, with 39% plants not conforming to environmental rules for discharge into streams, the CPCB's 2009 report said. Of the 522 working STPs across India, maximum are in the northern state of Punjab, which has 86. But no more than 38 work. Uttar Pradesh has the most working STPs (62), followed by Maharashtra (60) and Karnataka (44). An estimated 75% to 80% of water pollution is from domestic sewage, discharged untreated into local water bodies[4], [11], [12].

II. Existing Model

A. Scientific Idea (Microbial Fuel Cell)

The increased energy consumption along with unbalanced energy management has called in for serious awareness of renewable energy sources. Due to this increased interest in renewable energy, fuel cell technology [10], [11], [5] has gained importance in recent years. Microorganisms have proven to be promising agents for electricity generation. Microorganism, media and inoculum development are the materials and models used. The effluent from a rice mill was used for isolating the microorganism capable of degrading varying substrates. The isolated microorganism was characterized as Pseudomonas from the morphological and biochemical test results. The organism was maintained on minimal agar slants at 4 degree Celsius and sub cultured every month. Cells from agar slants were scrapped off and suspended in 10 ml of sterile water. The cell suspension was shaken thoroughly to break up any aggregates and was used as the inoculum in 100 ml of medium in 250 ml Erlenmeyer flasks. The suspension culture was grown at 30 degree Celsius on a rotary shaker at 240 rpm. The cells in the exponential phase were used for the experiments with the MFC. The studies were carried out in a medium which had the following composition (gm/l) beef extract 1.0, peptone 5.0, yeast extract 2.0 and sodium chloride 5.0. The initial pH of the medium was adjusted to 7.0 using 0.1 N potassium hydroxide and 0.1 N hydrochloric acid, prior to autoclaving (120 degree Celsius for 20 min).

B. MFC Construction & Operation

The MFC consisted of a 4.0 cm 4.0 cm 1.0 cm acrylic chamber with provision for the electrode and the inlet. The setup was assembled using steel studding, washers and nuts, and physically separated by a cation exchange membrane (NCBE Reading, University of Reading, UK) having 16 cm surface area. Each chamber contained a sheet of carbon fibre electrode tissue (NCBE Reading, University of Reading, UK) with a projected surface area of 18 cm, along with one graphite rod and connected using copper wires. All the reagents used in the microbial fuel cell were made in 0.1 M sodium phosphate buffer, pH 7.0.Five cells were connected in series (Fig. 1). The anodic and cathodic solutions were charged into the respective chambers [6],[9]. The cell was run in batch mode and in continuous mode. Solutions were pumped using a peristaltic pump at a flow rate of 10 ml/min with minimum variations. In the continuous mode of operation, the movement of solution from one chamber of an MFC, to the adjacent MFC chamber was maintained by gravity. Potassium ferricyanide (0.02 M) was taken in one chamber. In the other chamber, equal volumes of culture broth, wastewater and mediator (0.01 M) were added. The observations were recorded for 6 h. The experiment was conducted using methylene blue and neutral red as mediators.

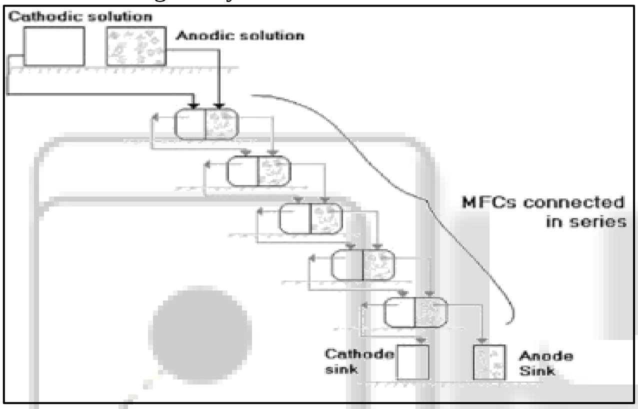

Fig. 1: Microbial Fuel Cell Experimental Setup

C. Implementation & Working Condition (Karstic Water Treatment)

Karstic spring waters are regularly subject to high levels of turbidity, which also includes a large number of bacteria. Membrane filtration represents a technology that copes ideally with these fluctuating conditions. In the last ten years, WABAG has completed more than ten membrane filtration projects for the treatment of karst water. The first of these was the installation of a submerged ultrafiltration plant [11], [13] (outside-in hollow fibre) as a single treatment stage for the district of Tavannes in Switzerland. This two-line system (2,400 m3/day) safely treats raw water with heavily fluctuating turbidity (including a high number of bacteria). Figure. 2 shows the UF process units (ZEEWEED 1000; 1,680 m2 membrane area each; polyvinylidene fluoride [PVDF]; nominal membrane pore size 0.02 µm).

Fig. 2: Submerged Ultrafiltration Units

D. Panipat Refinery Expansion Water Reclamation Plant (Pre-Warp) Design

Basically, the reclamation plant (design capacity =900 m3/h) incorporates clarification, pressure dual media filtration, ultra-filtration and reverse osmosis (two passes each with low-fouling composite membranes and a brine concentrator with seawater membranes). The RO permeate is polished by mixed bed, ion exchange filters and is then mostly recycled as boiler make-up water in the refinery power plant (Figure. 3) .Practically the same UF and RO membranes are employed in both plants. The ultra-filtration process [12], [10] steps consist of pressure-driven, inside-out, hollow fibre systems. Both systems are operated in a dead-end mode. Ferric chloride is dosed into the feed as a coagulant (typical dosing concentration: 1 mg Fe /L). The major task of the UF is to as reduce the silt density index (SDI) and remove turbidity, well as suspended and colloidal matter, in order to minimize fouling of the downstream reverse osmosis process step. The UF membrane fouling caused by the aforementioned impurities is removed by regular backwashing with permeate. The backwash is enhanced once a day in both UF plants using chemicals. Based on the extensive experience gained from previous projects, the PRE-WRP UF system was designed with a higher flux (net flux of PRE-WRP = 46 L/m2h). The resulting membrane areas total 16,416 m2 in the PRE-WRP UF. The retentate of the PRE-WRP UF process step is recycled (together with the DMF backwash water and the mixed bed ion exchange regenerate) to the equalisation tanks (feed collection tanks) upstream of thepre-treatment stages of the reclamation plant. The retentate of the ER-WRP UF is recycled (together with DMF back wash water and the RO II brine) to the inlet of the clarifier.

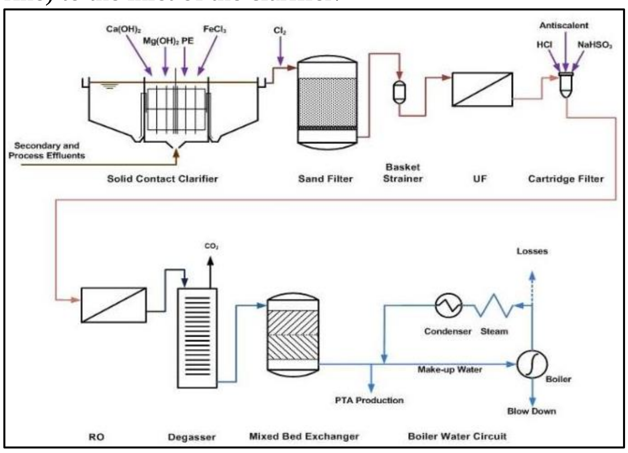

Fig. 3: PRE-WRP Process Flow Diagram

E. Treatment Systems in South East Asian Countries

In Southeast Asia, there is a high incidence of untreated industrial wastewater being discharged into sewers and natural water bodies, although most of the countries require that industrial wastewater should be treated before discharge [9], [11]. This happens because government monitoring, control and enforcement of environmental regulations is either missing or inadequate. There is, therefore, increasing concern over groundwater being polluted with nitrates and micro-organisms in the leachate from industrial landfills or dumps. Malaysia has the safest water supplies but elsewhere you should either buy bottled water or use a filter. Standards are lowest in Cambodia and Laos. In every small town you should be able to find water in 1 litre water bottles at a minimal cost. In Laos, these bottles are sold less than one dollar. The price is similar in Thailand and Cambodia. Occasionally in Cambodia we could only find small bottles of water about 300ml each and they are a bit more expensive. They face a lot of tragedies to obtain pure water

The common treatment systems used for industrial wastewater in ASEAN countries include:

- Oil interceptors – physical systems to capture oily discharges, allowing separation of oil from water.
- Balancing/equalization tanks – to homogenize variations in wastewaters over time or from different sources.
- Sedimentation/settling/clarifying systems - physical systems to enable the separation and removal of settleable solids from the water.
- Neutralization systems – adjustment of pH , acidity or alkalinity of the wastewater, to required levels for further treatment or discharge
- Chemical treatment systems [7], [8]– chemical process to either precipitate out the polluting compound (e.g. a heavy metal like copper) or cause destruction of the pollutant (e.g. cyanide) so that these can be removed from the treated wastewater, using coagulants/flocculants.
- Activated sludge systems – a biological treatment system to reduce the organic pollutants in wastewater.
- Biological filtration systems – uses biological growth to reduce organic pollutants in wastewater being filtered.
- Ion exchange systems – used for removing inorganic pollutants, normally complex compounds of heavy metals in wastewater.
- Activated carbon absorption –used for reducing fine organic contaminants, such as color pigments and odor-causing organic pollutants.
- Other aerobic and anaerobic systems – a large number of technologies are available in the form of biological systems, with aeration (aerobic), or in the absence of oxygen (anaerobic).

III. Proposed Model

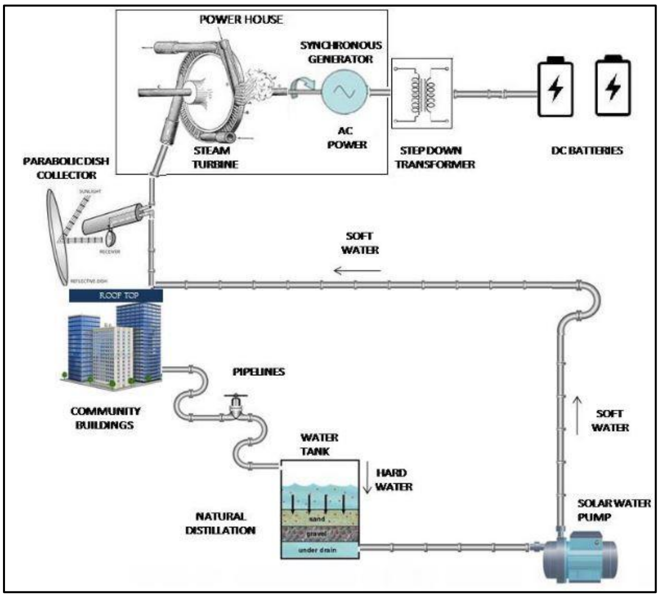

Fig. 4: Treated Water Environment

IV. Operation

A. Community Buildings

Community building is a field of practices directed toward the creation or enhancement of community among individuals within a regional area (such as a neighborhood) or with a common interest. It is sometimes encompassed under the field of community development. These buildings are most commonly developing in a rapid stage in metropolitan cities. The household waste water of each house is collected through the common pipelines and stored in the underground collection tank.

B. Collection Tank

Collection tank is made up with dual storage capacity, which is separated by a membrane of pebbles to perform the process of natural distillation. This water purification technology occurs naturally without energy required. This membrane will allow the water but not the majority of solid wastes. Natural filtration does not need any turbulent technology to push hard water through the membrane as it is done naturally with the help of gravitational force[1], [9]. To avoid buildup of contaminants, cross flow filtration allows water to sweep away contaminant build up and also allow enough turbulence to keep the membrane surface clean. After obtaining soft water it is passed through pipes to solar pumps. In these pipes organic liquidity (like water feeds, Agricultural waste, paper pulp etc.,) is added with the help of manual intervention (Manual intervention means that human intervention is needed to finalize your assessment. The system can't finalize the assessment automatically) to avoid the foul smell.

C. Solar Pump

In case of apartments, the water should be pumped to the roof of the building. Solar pumps [10], [11], [12], [13] can be used to pump the water. A solar-powered water pumping system is composed of a power source consisting of one or more PV (photovoltaic) panels. This current then flows to a control box which manages the power generated. Using a program called

Maximum Power Point Tracking the control box can regulate the speed of the pump motor so it runs at best efficiency. It also protects the pump motor from over voltage or low power situations. It can also start and stop the pump based on input from sensors and at the same time displaying the systems status. Whenever the sun shines the current turns the motor and the pump operates. If there is a requirement to run the pump for longer hours eg at night then a battery system must be included. This can store electricity during the day to run the pump later but it does require more solar panels to charge the battery. In early systems the motor was driven by DC current [2], [10] through brushes (brushes needed to be replaced periodically). Today's modern systems use high efficiency brushless motors which are driven by an alternating current produced by the control box.

D. Parabolic Dish Collector

The solar dish is formed into a paraboloid shape by stamping them out from thin sheet metal or thin aluminium coated Mylar, and which themselves can be anywhere between a few feet to several meters in diameter. The parabolic dish collects the incoming solar energy directly from the sun and concentrates or focuses it on a small focal point area positioned in front of the dish. The parabolic solar dish is covered with many small mirror reflectors all around its shape to help concentrate the thermal energy into a single focal point were the heat absorber is located producing more overall thermal energy per square meter of dish. These highly polished mirrors can reflect more than 90% of the sunlight that hits them increasing the efficiency of the dish by more than 20% compared to the parabolic trough collector. Mirrors are generally used instead of a single highly polished dish because they are relatively inexpensive, can be easily cleaned and last a long time in an extreme outdoor environment, making them an excellent choice for the reflective surface of a solar dish collector. Also individual mirrors can be easily changed if damaged.

As well as the solar dish collector, some form of thermal receiver is required to convert the focused beam of intense solar energy into heat. The solar receiver can be as simple as a small evacuated tube or a more complex solar heat engine, such as a Stirling Engine. Due to the very high temperatures at the focal point, a thermal oil type fluid is generally used instead of water inside the receiver, which transfers the intense heat created by focusing the sunlight on the receiver. Like the trough collectors, solar dish collectors can be used singly or linked together for larger industrial type applications.

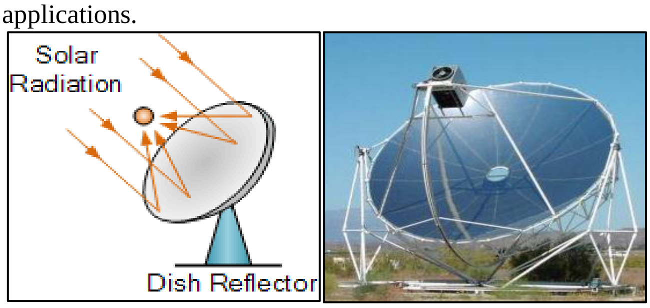

Fig. 5: Parabolic Dish Collector

E. Parabolic Solar Dish Collector

Solar Dish Collector type systems can also be part of another solar technology called a "solar dish-engine" system. The dish part of a solar dish engine system is very similar to the one described above, but may include many individual but smaller parabolic mirrors instead of one large single dish all angled and focused to the same focal point. Electricity is generated when the concentrated light is converted to heat, which drives a heat engine (usually a steam turbine) connected to an electrical power generator or powers a thermochemical reaction. Heat storage in molten salts allows some solar thermal plants to continue to generate after sunset and adds value to such systems when compared to photovoltaic panels. Then the water in the pipes are converted to steam and passed to the steam turbine to generate electricity.

F. Steam Turbine

Electrical energy generation using steam turbines involves three energy conversions, extracting thermal energy from the fuel and using it to raise steam, converting the thermal energy of the steam into kinetic energy in the turbine. High pressure steam is fed through a set of fixed nozzles in the turbine stator to the turbine rotor and passes along the machine axis through multiple rows of alternately fixed and moving blades. From the steam inlet port of the turbine towards the exhaust point, the blades and the turbine cavity are progressively larger to allow for the expansion of the steam. The stator blades in each stage act as nozzles in which the steam expands and emerges at an increased speed but lower pressure. As the high velocity steam impacts on the moving blades it imparts some of its kinetic energy to the moving blades. A rotary generator (synchronous generator) is used to convert the turbine's mechanical energy into electrical energy.

G. AC Power to DC Power

Alternating current (AC) obtained from the synchronous generator is the most efficient way to deliver electrical power. However, most electronic devices need direct current (DC) to function. For this reason, AC to DC converters is either a part of devices themselves. Step down transformer is used to output the low-voltage AC from high-voltage AC. Electrical current enters the primary coil of the transformer and induces a current in the secondary coil, which has fewer coils, resulting in a lower voltage. Little power is lost in this process because the amperage increases in relation to the decrease in voltage.

A rectifier usually consists of 4 diodes arranged in a diamond shape -- a type called a bridge rectifier. A diode only allows current to pass in 1 direction; the diamond configuration allow 2 diodes to pass the positive half of the current and the other 2 diodes to pass the negative half. The output of both sets is a current that climbs from 0 volts to the maximum positive voltage. Then the DC power is stored in batteries and used for running home appliances.

V. CHALLENGES & ITS SOLUTIONS

In the collection tank, water level sensor is placed in the terminal point (beyond which water cannot be stored) to prevent the over flow of water. If the water reaches the terminal point, it is detected by the water level sensor. Another pipe along with the valve is placed in the side wall of the tank near sensor and the other end is connected to public disposal area. If the water reaches the level then automatically sensor detects and the valve is opened to drain the hard water to the drainage.

Due to continuous flow of water foul smell will arise in the pipes. To prevent the foul smell, organic wastes (like Agricultural waste, paper pulp) can be added with the help of manual intervention.

Due to some natural issue there is possibility of leakage of steam which leads to environmental pollution. In order to prevent this, gas sensor is placed in the pipes which is between steam turbine and synchronous generator. If the leakage is detected then the emergency shutters placed in the pipes are closed total power shut down is done.

VI. FUTURISTIC SCOPE

Wastewaters are treated in many other ways. Currently, most plants use a combination of biological and chemical waste stabilization. Increasingly, the U.S. Environmental Protection Agency (EPA) is presenting the idea of making wastewater effluents cleaner in terms of nutrients. This forces most plants to add more chemicals to polish their effluents. The other unintended effect is that multiple systems now need more maintenance. Wastewater plants are having trouble maintaining complicated systems and keeping costs down. This treatment does not need more maintenance which also will provide promising solution. In future, municipality can undertake this process and renovate the collected wastewater. It also reduce the risk of disposal and could produce some additional clean electricity. It can be distributed via Electricity Board.

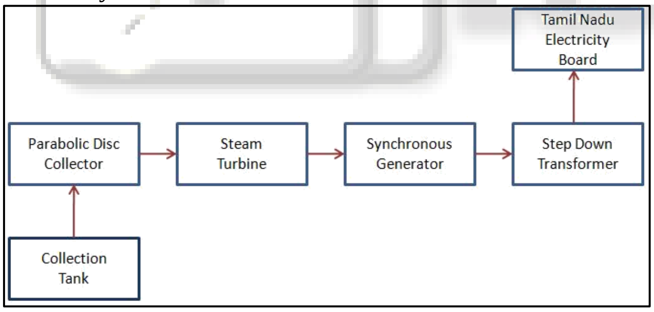

Fig. 6: Distribution of Electricity

VII. CONCLUSION

It is hoped that higher efficiencies in and effectiveness of the systems would allow less waste and better recycling of the resources. Perhaps more facilities will utilize closed-cycle systems, making rivers safer and environmentally friendlier. It is important to recognize that electricity is not mined or harvested, it must be manufactured. It is a promising method to satisfy dual needs, one by generating vital electricity from non-renewable resources and other is a new process to treat wastewater. In India, most of the percentage of wastewater is drained into natural water bodies which results in production of many diseases. If this idea is implemented in community buildings, industries, municipalities etc., then the wastewater will never ever be dumped in seas and rivers in the name of disposal. Simultaneously these dumps can be used to generate power which is much essential. Although fossil fuels are used for the production of electricity, they also take part in environmental pollution. Today we are in a need to adapt a new method to solve these two problems. So we came up with the solution of renovating wastewater to electricity.

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