Perspectives of Wastewater Recycling and Reuse in Changing Global Climate: BMP's in Water Technology

Dr. M.B. Chougule
Associate Professor
Textile and Engineering Institute, Ichalkaranji Maharashtra, India

Abstract— Water is important to all living things. Now a days changing global climate has given rise to unreliable rainfall. Unpredictable and inadequate rainfall is a challenge to protect our water resources for future generation. We receive water through rainfall. This is very unfortunate that most of the water flows down the rivers and reaches the sea, thus it remains unused. We are a witness to the emptied and dried up rivers, ponds, wells and tube wells. Therefore water crisis is not new for any country. Recycled water is a reliable source of water that must be taken into account in formulating a sustainable water policy. Water reuse is increasingly been integrated in the planning and development of water resources in many countries. This paper focuses on various innovative approaches in wastewater recycling and reuse.

Key words: Wastewater, Water Technology, Recycling, Reuse, BMP

I. Introduction

Water recycling and reuse is meant to help close the water cycle and therefore enable sustainable reuse of available water resources. When integrated to water resources management, water reuse may be considered as an integral part of the environmental pollution control and water management strategy. It may present benefits to public health, the environment, and economic development. Recycled water may provide significant additional renewable, reliable amounts of water and contribute to the conservation of fresh water resources. The significance of water reuse may be evaluated through the comparison of water reuse potential with total water use. Water recycling and reuse is generally small compared with total water use but it is expected to increase significantly. In most of the countries, wastewater is widely reused at different extents within planned or unplanned systems. In many cases, raw or insufficiently treated wastewater is applied. In other cases, wastewater treatment plants are often not functioning or overloaded and thus discharge effluents not suitable for reuse applications. Wastewater is a combination of the liquid, or water carried wastes, removed from domestic, institutions, commercial and industrial establishments together with surface/ ground/storm water. Waste water categories are Water treated after domestic & public uses, Industrial waste water, Saline agricultural drainage water, brackish ground water and Sea water in coastal regions. The use of waste water recycled requires a proper sustainable & manageable approach. The Value of recovery and reuse much more than what is apparent.

A. Challenges in the Waste water Recycling and Reuse

There are several challenges plaguing in wastewater recycling and reuse

- Economic considerations of water management on the government level.
- Health safeguards for the people consuming the produce grown using recycled water; health aspects of the residents of neighborhoods near irrigated areas, and the health of operators of irrigation who come in contact with waste water recycled after treatment or otherwise.
- Measures needed for the prevention of contamination and saltification on land and protect surface and ground water sources.
- Regulation of the level of nutritional material liquefied in water; make it suitable to the requirements of the vegetation and protection from residue levels.
- Selection of the appropriate crops for wastewater attributes; expulsion of growth inhibiting liquefied materials and poisons.
- Solution for clogging and fouling of equipment and dispensing water for irrigation while safeguarding a sound functioning of the system.

Basic challenges before implementation of wastewater recycling and reuse project.

- Lack of funds.
- Lack of awareness (benefits of treating/managing waste amongst users, technology options etc.)
- Lack of effective enforcement and stringent penalties on illegal dumping of wastewater
- Lack of trained manpower in managing water and wastewater treatment systems
- Lack of priority for investment in water and wastewater treatment systems in the municipal sector and the process of awarding bids to the lowest cost bidder, many times ignoring technology advantages and lifecycle cost as parameters for awarding contracts.

II. Components Of Wastewater And Innovation Necessary For Treatment

Following are components of wastewater and innovative treatment practices are having challenges to treat this to desired level.

- Suspended solids
- Soluble/ biodegradable organic matters
- Inorganic soluble salts – Ca, Mg, Na, K, B, CL, carbonates and sulphides
- Plant micro-nutrients – N, P, K
- Faecal pathogenic micro-organisms
- Trace elements: Heavy metals: As, Cd, Cr, Cu, Pb, Hg, Zn
- Inorganic elements: Al, Be, Co, F, Fe, Li, Mn, Mo,Se, Sn, Ti, W and V

III. India's water –the impending crisis & the challenge

The outlook for sustainable development and environment protection would be recycle and reuse of municipal wastewater apart from augmenting water supplies through alternate sources. Per Capita Water Availability in India and demand of water is given here.

Per Capita Water Availability

- 1951 5177 Cubic meters per annum
- 2001 1869 Cubic meters per annum
- 2025 1341 Cubic meters per annum
- 2050 1140 Cubic meters per annum

There is a rapid increase in demand for water in various sectors

- 2000 – 634 Cu.m per person
- 2025 – 822 Cu.m per person

IV. POTENTIAL TO AUGMENT FUTURE DRINKING WATER SUPPLIES

New analyses suggest that the possible health risks of exposure to chemical contaminants and disease-causing microbes from wastewater reuse do not exceed, and in some cases may be significantly lower than, the risks of existing water supplies. Wastewater reuse is poised to become a legitimate part of the nation's water supply portfolio given recent improvements to treatment processes. Although reuse is not a panacea, wastewater discharged to the environment is of such quantity that it could measurably complement water from other sources and management strategies.

It is necessary to examine a wide range of reuse applications, including potable water, non-potable urban and industrial uses, irrigation, groundwater recharge, and ecological enhancement. Many communities have already implemented water reuse projects -- such as irrigating golf courses and parks or providing industrial cooling water in locations near wastewater reclamation plants. Potable water reuse projects account for only a small fraction of the volume of water currently being reused. However, many drinking water treatment plants draw water from a source that contains wastewater discharged by a community located upstream; this practice is not officially acknowledged as potable reuse.

It is necessary to focus on wastewater treatment technologies for mitigating chemical and microbial contaminants, including both engineered and natural treatment systems. These processes can be used to tailor wastewater reclamation plants to meet the quality requirements of intended reuse applications. Moreover, new analyses suggest that the possible health risks of exposure to chemical contaminants and disease-causing microbes from wastewater reuse do not exceed, and in some cases may be significantly lower than, the risks of existing water supplies.

V. WASTEWATER REUSE AS BMP'S IN WATER TECHNOLOGY

The use of BMP's plays a key role in facilitating freshwater protection and integrated water resource development and management. Wastewater reuse applications cover a wide range, including industrial, residential, recreational, and environmental enhancement purposes, as shown in Fig. 2.

Water and wastewater reuse has various benefits. First, recycled wastewater can serve as a more dependable water source, containing useful substances for some applications. For example, the quantity and quality of available wastewater may be more consistent compared to freshwater, as droughts and other climatic conditions tend to have a less pronounced effect on wastewater generation. With adequate treatment, wastewater can meet specific needs and purposes, such as toilet flushing, cooling water, and other applications.

The reuse of treated wastewater is particularly attractive in arid climates, areas facing demand growth and those under water stress conditions. Some wastewater streams also contain useful materials, such as organic carbon and nutrients like nitrogen and phosphorous. The use of nutrient-rich water for agriculture and landscaping may lead to a reduction or elimination of fertilizer applications.

The second benefit of wastewater reuse is that it leads to reduced water consumption and treatment needs, with associated cost savings. In many applications, reusing wastewater is less costly than using freshwater, with savings stemming from more efficient water consumption and a reduced volume of additional wastewater treatment, as well as associated compliance cost savings.

The infrastructure requirements for advanced water and wastewater treatment may also be reduced. For instance, many areas with adequate water resources and a growing urban population have experienced increased water consumption, both on a per capita and total basis. Meeting such a growing demand often requires the additional development of large-scale water resources and associated infrastructure. By meeting some of the water demand through wastewater reuse and efficiency improvement, additional infrastructure requirements and the resulting financial and environmental impacts can be reduced or, in some cases, eliminated altogether.

Finally, by reusing treated wastewater for these applications, more freshwater can be allocated for uses that require higher quality, such as for drinking, thereby contributing to more sustainable resource utilization. Wastewater reuse can thus be considered as an appropriate application of ESTs as shown in Fig. 2.

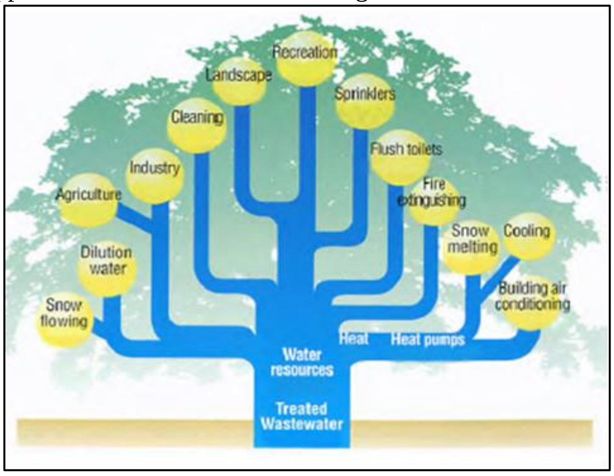

Fig. 1: Tree of Water Resources Recycling

VI. BASIC PRINCIPLES OF WASTEWATER TREATMENT

In order to reuse wastewater, it is necessary to treat raw wastewater to meet specific needs a public safety. In this section, some basic information on wastewater treatment technologies is given and the terminology explained.

Wastewater treatment processes can be categorized into the following three:

- Physical process: impurities are removed physically by screening, sedimentation, filtration, flotation, absorption or adsorption or both, and centrifugation;
- Chemical process: impurities are removed chemically through coagulation, absorption, oxidation-reduction, disinfection, and ion-exchange;
- Biological process: pollutants are removed using biological mechanisms, such as aerobic treatment, anaerobic treatment and photosynthetic process (oxidation pond).

Conventional wastewater treatment consists of the following stages: preliminary, primary, secondary, and disinfection. Municipal wastewater treatment facilities use combinations of physical, biological and chemical treatment technologies. Preliminary and primary treatments are usually physical processes, such as screening for the removal of debris and large solids, and sedimentation. A secondary treatment may utilize biological processes, such as stabilization ponds, trickling filter, oxidation ditch, and activated sludge, which is then followed by sedimentation of biomass (sludge). Tertiary and advanced treatment is an additional treatment for higher-level removal of specific pollutants, such as nitrogen or phosphorus, which cannot be removed by conventional secondary treatments.

VII. INNOVATIVE WASTEWATER TREATMENT IN WASTEWATER RECYCLING AND REUSE

A. Membrane Filtration Technologies

In Membrane filtration has increasingly been utilized as an effective measure to obtain higher quality water from wastewater and seawater. It is a process of separating materials based on their particle size and other compound properties by letting water through membranes using pressure and concentration. Membrane filtrations are classified according to the size of materials. Fig. 2 shows Reverse Osmosis membrane modules.

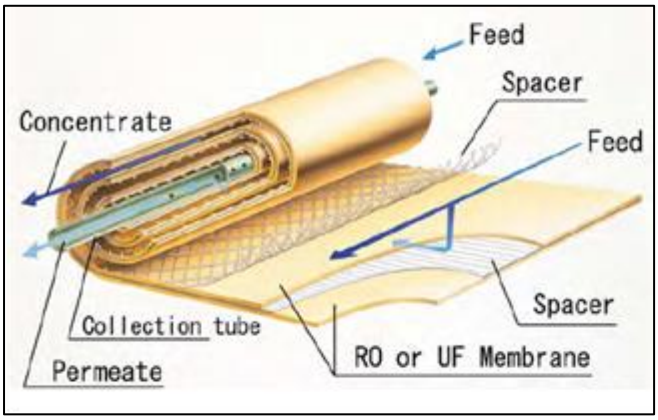

Fig. 2: Reverse Osmosis Membrane Modules

B. Up-Flow Anaerobic Sludge Blanket (UASB) and Acronyms

To improve effluent quality, the UASB process is mostly followed by post treatment processes like extended aeration lagoon, stabilization pond, biological activated sludge, physical sand filtration to remove macronutrients, pathogens and organic materials, which is a limitation of the UASB process. In the Indian scenario, performance of UASB followed by post treatment shows considerably good results, with an average removal efficiency of BOD, COD and TSS up to 70%, 75% and 74% respectively. No doubt, the conventional treatment offers an advantage in terms of efficient treatment but looking into the economy, energy consumption, land requirement and ease of handling, a set of treatments is proposed in the Indian context for wastewater reuse as shown in Fig. 3.

The final water obtained through the proposed set of arrangements (Fig.2) will have the quality of water that is needed for day-to-day use, except for drinking (BOD5 <3 mg/l, turbidity <2 NTU, and coliform <1 log). The UASB process has advanced over a period of time and has promising potential to treat ww in countries like India, with further treatment for reuse of treated ww (Fig.2). The widespread application of membranes has made ww reuse at an affordable cost, offering an effective solution for the removal of most of the impurities along with microbes.

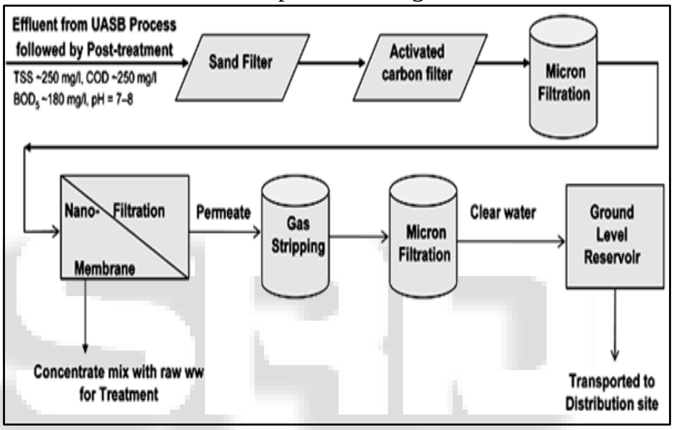

Fig. 3: Reverse Osmosis Membrane Modules

C. Up-Flow Anaerobic Sludge Blanket (UASB)

Wastewater can be treated by the biofilter absorbent trickle filter technology. The biofilter foam medium forms an interconnecting, three-dimensional reticulate solid framework with high surface area, high porosity, high absorption, and dual pathways for air and wastewater. The absorbent trickle filter is treating residential, restaurant, and commercial golf clubhouse wastewater effectively, and the effluent is reclaimed as a resource rather than a waste product. Simple treatment steps such as septic tanks, recirculation, and up-flow filters ensure consistency of aesthetic quality to overcome suspicion by the end user. Depending on level of end use, components can be added for additional treatment.

D. Nano Filtration

Nano filtration is used to remove particles in the 300 to 1000 molecular weight (MW) range, rejecting selected salts and most organics and microorganisms, operating at higher recovery rates and at lower pressures than RO systems. Even though most inorganic and organic constituents and microorganisms are removed, disinfection is required to ensure system reliability in the event of a leak or defect in the membrane. Fig. 4 shows use of Nano filtration,

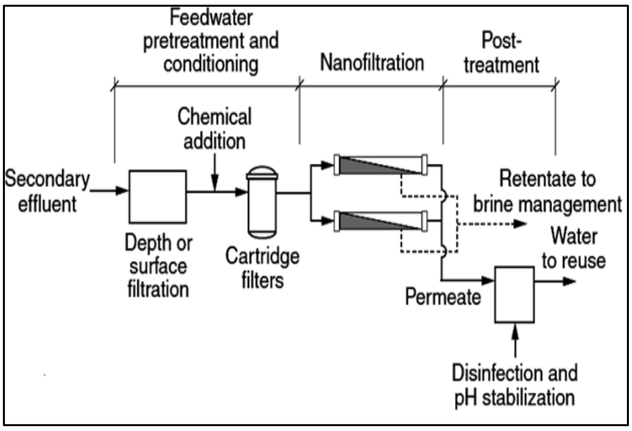

Fig. 4: Nano Filtration

E. Electrodialysis

Electrodialysis (ED) is an electrochemical separation process in which mineral salts and other ionic species are transported through ion-selective membranes from one solution to another under the driving force of a direct current (DC) electric potential. As compared to NF and RO, which transports pure water through the membrane leaving the salts behind, with ED salt is gradually stripped from solution leaving a dilute solution behind containing particulate matter and neutral species not removed by the ED process. The salt transferred through the membrane then forms the concentrate. The key to the ED process is the ion selective membranes that are essentially ion exchange resins cast in sheet form. Ion exchange membranes that allow passage of positively charged ions such as sodium and potassium are called cation membranes. Membranes that allow passage of negatively charged ions such as chloride and phosphate are called anion membranes. To demineralize a solution using ED, cation and anion membranes are arranged alternately between plastic spacers in a stacked configuration with a positive electrode (anode) at one end and a negative electrode (cathode) at the other (see Fig. 5). When a DC voltage is applied, the electrical potential created becomes the driving force to move ions, with the membranes forming barriers to the ions of opposite charge. Therefore, anions attempting to migrate to the anode will pass through the adjacent anion membrane but will be stopped by the first cation membrane they encounter. Cations trying to migrate to the cathode will pass through the cation membrane but will be stopped by the anion membrane. The membranes, therefore, form ion diluting compartments and ion concentrating compartments.

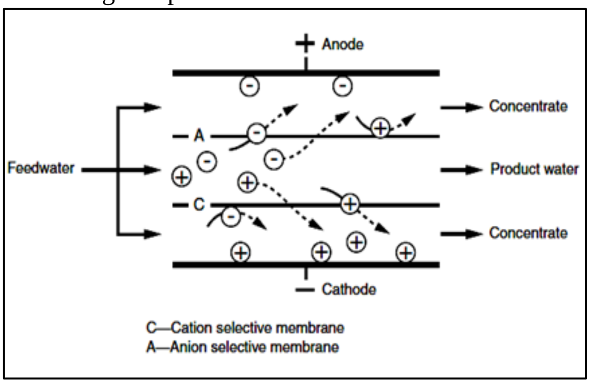

Fig. 5: Electrodialysis (Ed) -Electrochemical Separation

VIII. CONCLUSION

The climate change impacts such as variations in temperature and alarming droughts have become frequent. Water is an infinite resource is one of the reasons for water shortage in many water deficit areas in India. Treated wastewater reuse is one important option which can be promoted as important concept of "Integrated urban water management". Costs of water reuse for potable and non-potable applications vary widely because they depend on site-specific factors.

Recycled water can satisfy most water demands, as long as it is adequately treated to ensure water quality appropriate for the use. Water recycling projects must be developed with innovative treatment approaches to meet non-potable water demands, a number of projects use recycled water indirectly for potable purposes. These projects include recharging ground water aquifers, augmenting surface water reservoirs with recycled water, meeting Industrial demand also.

REFERENCES

[1] Jowett E.C., "Re-use of treated sewage using biofilter technology", CMHC, ClubLink Corp., Waterloo Biofilter Systems, 2003, pp 1-7
[2] Takashi Asano, "Water Reuse Issues, Technologies, and Applications", Metcalf & Eddy, 2007, pp 501-503.
[3] Water and wastewater reuse "An Environmentally Sound Approach for Sustainable Urban Water Management" United Nations environment programme, http://www.unep.or.jp/
[4] Jowett, E. C., and M. L. McMaster. On-site wastewater treatment using unsaturated absorbent biofilters, Journal of Environmental Quality. vol. 24, , 1995, pp. 86--95.
[5] Renu Rajaram "The future lies in recycle and reuse of municipal wastewater" http://www.projectsmonitor.com/WATTREAT/the-future-lies-in-recycle-and-reuse-of-municipal-wastewater

