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Sarraf, Shradha
Department of Civil Engineering, National Institute of Technology Kurukshetra

Deswal, Surinder
Department of Civil Engineering, National Institute of Technology Kurukshetra

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Life Cycle Assessment of a Water Treatment Plant based on Non-Conventional Moving Bed Biofilm Reactor Process

Shradha Sarraf[1], Surinder Deswal[2*]
[1,2]Department of Civil Engineering, National Institute of Technology Kurukshetra, India

*Author to whom correspondence should be addressed:
E-mail: sdeswal@nitkkr.ac.in

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Abstract: The present study aims to develop a tool based on the Life Cycle Assessment approach considering multiple environmental indicators that can be systematically used for environmental evaluation of water treatment plants, and to recognize the environmental weak points of the plant that in turn leads to the identification and implementation of sustainable national water management policies that augment in achieving the United Nations Sustainable Development Goals (SDGs). The quantitative environmental evaluation of the water treatment plant reveled that electricity consumption primarily contributes to the majority of impact areas and indicators. As a result, an emphasis needs to be made on the use of green electricity generated from renewable resources to offset environmental concerns.

Keywords: life cycle assessment; water treatment plant; environmental indicators; SDGs

1. Introduction

Water is indispensable to life and despite its abundance, freshwater is one of the major crisis the world is facing today. According to an estimate, about one tenth of people (771 million) does not have access to safe drinking water[1], and over 2 billion people are living in countries that have inadequate water supply[2]. It is projected that one half of global population could be living in water scarce regions/countries by 2025[2]. Access to safe drinking water means availability of at least 20 liters of potable water per person per day from an improved source within 1 km of the consumer's dwelling[3].

India is one of the most water stressed country supporting about 18 % of the global population but having only 4 % of the global water resources. About 6 % of India's population (91 million people) lacks access to safe water and faces high to extreme water stress[4]. To address this issue, the development of water treatment projects in urban as well as rural areas has been taking place in India in mission mode so as to meet the growing demand of safe drinking water supply. To achieve this, it is equally important to have a sustainable water management policy that augment and strengthen the United Nations Sustainable Development Goal (SDG) 6 of achieving Clean Water and Sanitation for all by 2030. All the 17 SDGs are interlinked with each other which ascertain that action in one sphere will affect outcomes in other areas, and that the future development must be balanced and sustainable socially, economically[5], and environmentally. Therefore, there is an urgent need to improve the sustainability of every industrial process and public amenities, including the water treatment projects for potable water supply, by incorporating environmental criteria in policy making process.

Life Cycle Assessment (LCA) is an established methodology by International Standardization Organization (ISO) for assessing the possible environmental implications of industrial processes – products or services[6], through all the life cycle stages by adopting cradle-to-grave approach[7, 8]. Several environmental evaluation or LCA studies have been reported of wastewater treatment processes, such as biological wastewater treatment plants[9], wastewater treatment alternatives for non-potable urban reuse[10], deionization technology[11, 12], sewage sludge treatment[13] and industrial effluent treatment processes[14] in the last couple of decades. But very few reported LCA studies of water treatment projects for public water supply[15].

The present paper aims at developing a tool for the environmental evaluation of water treatment plant based on non-conventional Moving Bed Biofilm Reactor (MBBR) technology. For this, LCA approach has been used systematically by considering multiple environmental impact indicators.

2. Literature review

In one of the earliest study, LCAqua software developed by KIWA Research and Consultancy was used for environmental evaluation or LCA to compare conventional water treatment plant based on granular activated carbon (GAC) filtration, and plant based on nano-filtration membrane process; wherein, it was reported that the highest environmental impact in both the cases was because of on-site consumption of energy (conventional: 50%; and nano-filtration: 65%) followed by GAC regeneration and softening[16]. In another similar study, LCAqua software was used to compare the environmental impacts of conventional water treatment plants using GAC using two different reverse osmosis treatment processes; and observed that consumption of electricity, GAC regeneration and chemical consumption had the highest environmental impact[17]. Fredrich[18] used GaBi software with CML method to compare the environmental burden due to conventional water treatment plant and water treatment plant based on ultra-filtration membrane process, and reported comparable and highest environmental impacts of 80% attributable to energy consumption in both the processes. Raluy *et al.*[19, 20] used GaBi software for environmental evaluation of water production techniques and reported that energy (electricity and heat) consumption has the highest environmental impact, and its influence can be reduced with green energy supply. Vince *et al.*[7] also reported highest burden on environment from energy consumption in potable water supply processes based on ground-water treatment, ultra- and nano-filtration, sea-water treatment by reverse osmosis and thermal distillation. The LCA of the Israeli water supply system also reported higher environmental impacts due to energy consumption, and recommended the use of electricity mix to a cleaner energy sources in future projects[21]. Zine *et al.*[22] used SimaPro 6 software developed by PRe Consultants for the evaluation of environmental impacts of potable water treatment station of Boudouaou (Algeria) and reported that the potential environmental impact was due to consumption of energy and chemicals used for coagulation and re-mineralization. The LCA study of drinking water consumption carried out in Barcelona city of Spain under different scenarios using SimaPro software revealed that reverse osmosis process employed at the treatment plant had twice the environmental impact compared to the adoption of domestic reverse osmosis primarily due to high energy requirement of treatment plant for the same process, and the bottled mineral water had the highest environmental implications due to significant consumption of raw material and energy for the production of bottles[23]. Decentralization of drinking water services (treatment and distribution) and adoption of renewable energy sources have been emphasized to reduce the system's effect on global warming in the LCA study of future water system scenarios for Mexico City[24]. Barjoveanu *et al.*[25] used LCA to analyze the water service system serving the community in Iasi City of Romania, and concluded that the environmental impact was mainly due to high energy usage for the abstraction as well as treatment and distribution of water.

All the above reviewed studies have reported energy consumption followed by chemical consumption being the major sources of environmental impact in case of water treatment plants irrespective of the technique and/or unit processes employed. Further, these reported LCA studies of water treatment plants have generally focused only on few of the environmental impact indicators, thereby suffering from limitations of complete environmental evaluation and thus diluting the SDGs to be achieved by 2030.

3. Materials and methods

3.1 Site description

The present study has been conducted on a water treatment plant (WTP) located at Sikandara in Agra city (Uttar Pradesh, India). The plant is based on Moving Bed Biofilm Reactor (MBBR) technology and is one of the most advanced water treatment plants in south Asia. The technology or process is based on the involvement of thousands of polyethylene biofilm carriers that operate in mixed motion within an aerated basin. High population density, commercial and industrial areas in the city, coupled with the non-conventional MBBR technology for water treatment process are the main considerations for selection of this WTP as a case study. The WTP has a design capacity of 144 million litres per day (*MLD*) that serves around 2,00,000 households. Raw water is extracted from Yamuna river (a perennial source) with the help of an intake pump-house on the bank of the river about 2 km from the WTP. In the year 2022, the volume of treated water was 28,015.58 million litres having supplied or billed volume of 27,315.19 million litres (about 374.18 litres per household per day) with a transmission loss of about 2.5%, and at an operational capacity of 76.76 *MLD* (53.30%). The key process units of the treatment plant include pre-settling tank with tube settlers, 2 mm fine screen with auto cleaning, moving bed bio-reactor (MBBR) process, continuous membrane filtration (CMF) utilizing ultrafiltration (UF) membrane, disinfection, sludge thickener and belt filter press (BFP) for sludge dewatering. The water quality of raw water (before treatment) and treated water (after treatment), as average of nine months (January – September, 2022), has been presented in Table 1.

Table 1. Water quality parameters of raw and treated water.

Parameter	**Unit**	**Raw water**	**Treated water**
pH	- -	7.96	7.37
Turbidity	*NTU*	156.78	0.00
TSS	*mg/L*	144.44	0.00
Total coliform	*MPN/100 ml*	1,94,961.11	BDL
BOD	*mg/L*	31.28	1.29
COD	*mg/L*	42.94	9.98
Total nitrogen	*mg/L*	26.02	6.41

Phosphorous	*mg/L*	3.47	0.17
Residual chlorine	*mg/L*	- -	1.50

The water quality parameters of treated water conform to Indian and World Health Organization (WHO) standards (permissible limits) for drinking water quality.

3.2 Methodolgy

In the present study, the environmental evaluation of water treatment plant has been carried out in accordance with ISO 14040 standardized LCA procedure by using GaBi software that has been developed by PE Consulting Group[26]. LCA comprises of four stages, namely goal and scope, inventory analysis, impact assessment and interpretation as per ISO 14040[28]. Data was collected using specially developed models (*LCA Modeling*) for water treatment processes, and GaBi Education Database 2020 for other industrial processes, namely chemicals and electricity production. Environmental impacts were evaluated using Environmental Footprint 2.0, one of the most comprehensive LCIA methods available as on date. The following indicators of environmental impacts have been investigated in the present study (Table 2):

Table 2. Indicators of environmental impacts.

Indicator (Impact category)	**Impact Area(s)**
Global Warming Potential (GWP)	Climate change
Acidification Potential (AP)	Climate change, and Human health
Human Toxicity (HT)	Human health
Respiratory Inorganics (RI)	Human health
Ionizing Radiation (IR)	Human health
Ozone Depletion Potential (ODP)	Human health, and Ecosystem quality
Eco-toxicity (ET)	Ecosystem quality
Terrestrial Acidification (TA)	Ecosystem quality
Water Scarcity (WS)	Resource depletion

The environmental impacts resulting from sludge disposal in landfills have to be evaluated by considering the local ecosystem. However, the present LCIA methods do not have the provisions to account for the ecosystem specificity[27]. Further, landfill data are not sufficiently available to assess the environmental impacts. Though, researchers are carrying out studies to assess the LCA of solid wastes including the sludge from the various water and sewage treatment plants; therefore, the environmental impacts of these indicators have not been consider in this study.

3.3 System boundary

The system that has been considered in this study is a water treatment plant, and the various functional units are the unit treatment processes at the WTP for the production of drinking water as per Indian standards. The system boundary thus considered in the study is the treatment process during operational phase as shown in Fig. 1; whereas, the characteristics and chemical dosing of each unit process within the system boundary are tabulated in Table 3.

In accordance with the previous studies[7], the following assertions have been considered as preliminary assumptions in the analysis:

- The average lifetime (design period) of a water treatment plant as 25 years.
- The plant construction phase[22], transport of raw materials[20], and decommissioning phase[18] have not been accounted for in the LCA due to its lower importance and negligible impacts on environment in comparison to the impacts during operational phase[29].
- The environmental impacts of sludge landfill have not been accounted for in the LCA due to lack of dependable data, as well as actual LCA restrictions and limitations.
- Electricity consumption has been accounted for by considering UCTE's (Union for the Co-ordination of Transmission of Electricity) average production mix.

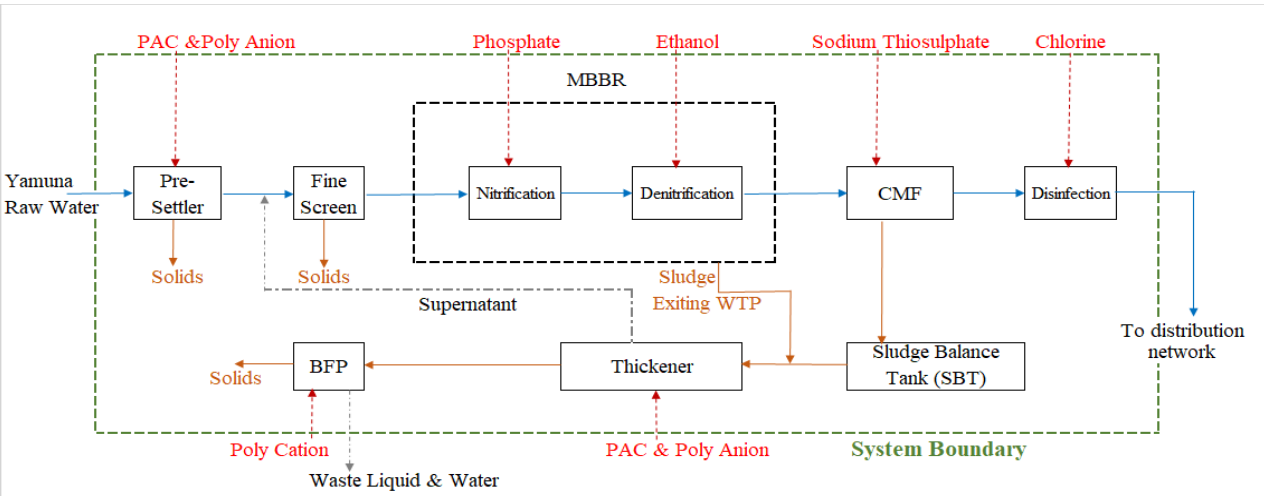

Fig. 1: Water treatment process within system boundary.

Table 3. Characteristics and chemical dosing of unit processes.

Unit Process	**Chemical**	**Dose Range (mg/L)**	**Parameters Control**
Pre-settler	Poly aluminum chloride (PAC)	5-30	TSS, Turbidity, Colour and pH less than raw water.
	Poly anion	0.1-0.4	
MBBR	Phosphoric acid	0.5	BOD, COD, DO, NH_3-N, NO_2-N, and NO_3-N.
	Ethanol	As per inlet NH_3.	
Ultra-filtration by CMF	Hypo (Sodium thiosulphate)	250	-
	Caustic	pH: 9.5-12	-
Disinfection	Chlorine	0.5-1.5	Pathogens
Sludge thickener	Poly aluminum chloride (PAC)	5-25	TSS, Turbidity, Colour and pH less than SBT parameters
	Poly anion	0.1-0.8	
Sludge dewatering	Poly cation	20-60	Separate solid particles

3.4 Life cycle inventory

Life cycle inventory (LCI) includes all the required inputs and generated outputs by the operation of the system's unit processes on which the environmental impacts of the system depend during its functioning. It is actually the mass and energy balance of each unit process within the system. In the present study of WTP, the LCI of the system includes:

- Consumption of energy (that is, electricity);
- Consumption of chemicals (PAC, poly anion, poly cation, chlorine, phosphoric acid, etc.); and
- Emissions to air and discharges to soil.

The general framework of the inventory analysis has been provided by the ISO. In this research, GaBi software has been used for inventory analysis. The maximum chemical doses have been taken in the inventory analysis for each unit process considering that the WTP has been currently operating below its design capacity. The primary data was collected directly from the WTP under study; thereafter, the secondary data was obtained using GaBi software, and the tertiary data (results) were finally obtained after computations and graphical plotting.

4. Results and discussion

The quantitative environmental impact assessment due to chemicals and energy consumption, individually and collectively, by the different unit processes of the system has been analyzed and discussed in terms of nine indicators (Table 1) so as to recognize the environmental weak points of the water treatment process that in turn leads to the identification and implementation of sustainability improvement strategies. The impact value for each indicator (impact category) has been presented as the equivalent weight of reference ions or gases, and compared for energy, chemicals, and combined (energy and chemicals) consumption. For example, Acidification Potential (AP) is being expressed by *mole of* H^+ *equivalent* for the production of total drinking water in the year 2022 by the water treatment plant.

4.1 Global warming potential (GWP)

The temperature rise caused by the release of greenhouse gases (GHGs) including CO_2, CH_4, N_2O, halogenated gases, etc. is known as global warming[30]. Fig. 2 shows the GWP for all the studied unit processes in the water treatment plant in terms of chemical and energy consumption individually and combining the both consumptions.

Sludge dewatering process has the highest GWP due to chemical consumption (567.23×10^4 *kg* CO_2 *eq*) followed by disinfection process (51.40×10^4 *kg* CO_2 *eq*), pre-settler process (46.10×10^4 *kg* CO_2 *eq*) and disinfection process (39.45×10^4 *kg* CO_2 *eq*). The chemicals used by these processes are poly cation and chlorine respectively that are more prone to GWP during manufacturing and usage. Whereas hypochlorite and caustic used in ultrafiltration have the least GWP (7.74×10^4 *kg* CO_2 *eq*) among all the unit processes.

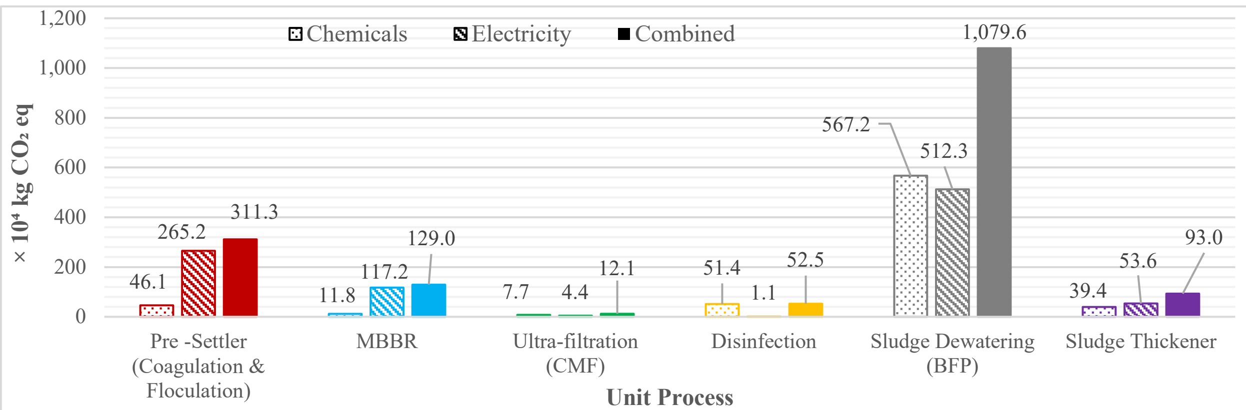

Fig. 2: Global warming potential of unit processes.

Sludge dewatering process also displayed highest GWP (512.34×10^4 *kg* CO_2 *eq*) when the consumption of electricity is considered followed by pre-settler process (Fig. 2).

4.2 Acidification potential (AP)

It is the environmental impact that measures the quantity of gases responsible for soil, ground and surface water acidification, and its consequences on animals, ecosystems and the built environment. Acidification results from the emission of compounds that are acidifying, such as NO_x, NH_3, and SO_x.

Due to chemical consumption, the AP of MBBR process (20,365 *mole of* H^+ *eq*) has been very high in comparison to other processes (105 to 1,002 mole of H^+ equivalent) as shown in Fig. 3. This is possibly due to the use phosphoric acid and ethanol to convert ammonia into nitrite and then to nitrate in the MBBR process. The results also revealed that the use of phosphoric acid has the highest AP in comparison to other chemicals used in the unit processes. Whereas, due to energy consumption, the highest AP of 65,519 *mole of* H^+ *eq* has been shown by sludge dewatering process that consumes 46,61,177.53 *kWh* of energy out of 86,79,380 *kWh* of total energy consumed in the plant.

After considering the combined effect of energy and chemical consumption, the sludge dewatering process has the highest acidification potential (66,728 *mole of* H^+ *eq*) followed by MBBR (35,353 *mole of* H^+ *eq*) and pre-settler (34,842 *mole of* H^+ *eq*) processes (Fig. 3).

4.3 Human toxicity (HT)

HT is a computed index measured in Comparative Toxic Unit for Humans (*CTUh*). It expresses the projected increase in morbidity in the overall human population per unit mass of a chemical released (that is, cases per kilogram of chemicals released). It is based on the chemical's intrinsic toxicity as well as its potential dosage.

Due to chemical consumption, pre-settling has the highest human toxicity-causing process (0.94×10^{-3} *CTUh*) followed by sludge thickening process (0.87×10^{-3} *CTUh*) as shown in Fig. 4. Both these processes use PAC and poly anion as chemicals for coagulation and flocculation, and have the potential to cause most human toxicity than other chemicals during manufacturing and their usage in the water treatment plant. The results also revealed that the chemicals used in the ultra-filtration process has the least impact.

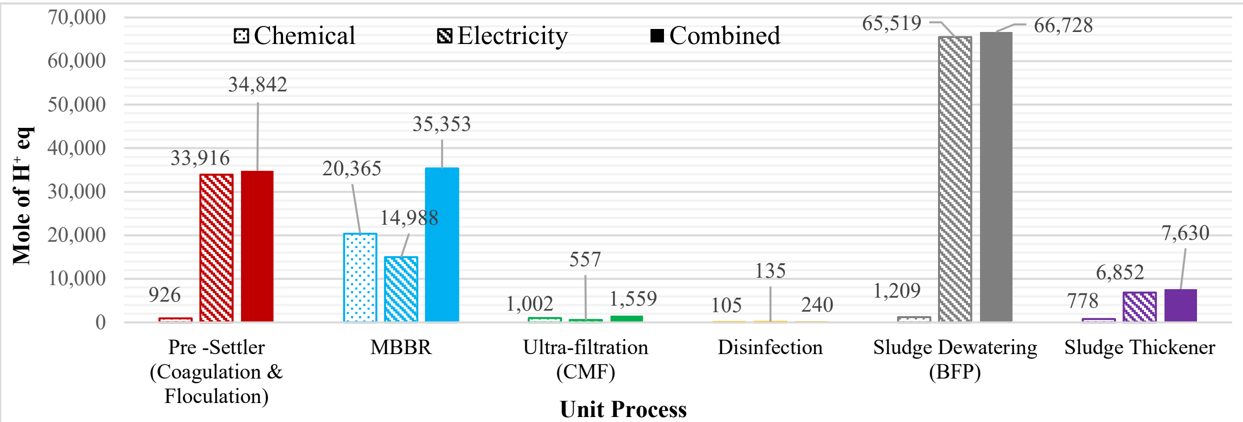

Fig. 3: Acidification potential of unit processes.

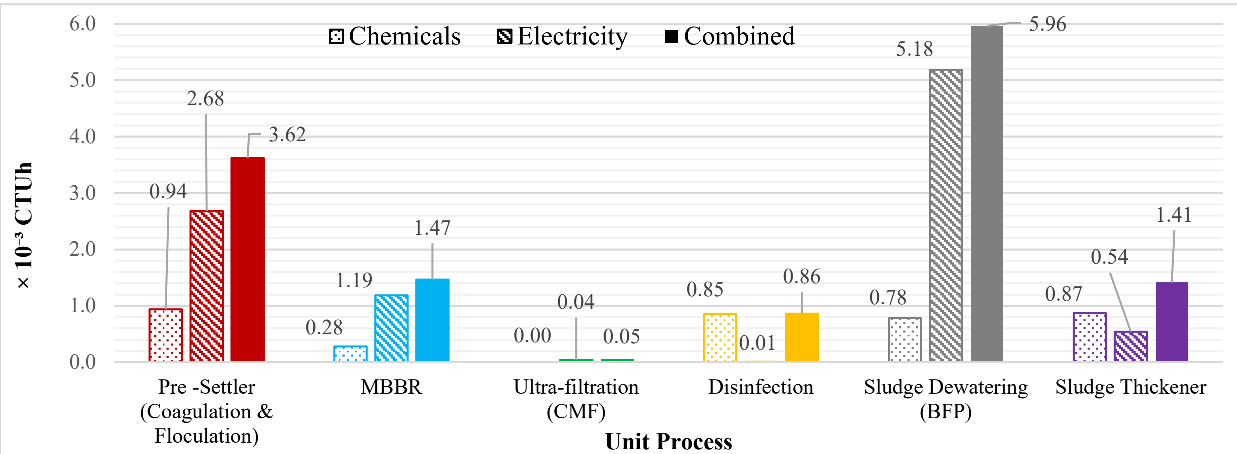

Fig. 4: Human toxicity potential of unit processes.

Sludge dewatering process has the highest HT potential due to electricity consumption (5.18×10^{-3} *CTUh*) and combined (chemical and electricity) consumption (5.96×10^{-3} *CTUh*) followed by pre-settler and MBBR processes primarily due to high electricity consumption among all the processes (Fig. 4). Thus, electricity consumption displayed the highest contributor to human toxicity potential.

4.4 Respiratory inorganics (RI)

Respiratory Inorganics are very tiny suspended particles of size 2.5 microns or less and are measured as $PM_{2.5}$ *eq*. They have the potential to cause respiratory damage in humans such as coughing, wheezing, sneezing, chest pain, shortness of breath, etc. aggravating to severe medical conditions such as asthma, lung cancer, and heart disease in case of long term exposure, and may cause premature death in extreme cases.

Due to chemical consumption, highest impact of respiratory inorganics (5.20 $PM_{2.5}$ *eq*) comes from the ultrafiltration process (Fig. 5) possibly due to the usage of hypochlorite. Due to energy consumption, sludge dewatering process has the highest impact of respiratory inorganics (1.11 $PM_{2.5}$ *eq*). Since sludge dewatering process consumes highest amount of energy among all the processes, so it can be inferenced that release of respiratory inorganics is directly proportional to the amount of energy production. Overall, the ultrafiltration process shown the highest release of respiratory inorganics (5.21 $PM_{2.5}$ *eq*) among all the processes (Fig. 5). Alternative eco-friendly chemicals could be considered for the impact reduction.

4.5 Ionizing radiation (IR)

Ionizing radiation is defined as an energy emitted by atoms that can move as electromagnetic waves (such as high frequency gamma and x-rays) or as sub-atomic particles (such as alpha particles, beta particles and neutrons). It has the potential for health hazards such as skin burns, damage to genetic material (DNA) or acute radiation syndrome. The LCA considers radiation emissions under normal working conditions (i.e., no accidents in any of the processes from manufacturing to use). The potential impact on human health due to exposure to various ionizing radiations is represented as the equivalent of kilo becquerels of Uranium 235 (*kbq* U_{235} *eq*).

The sludge dewatering process has the highest combined IR potential (56,879 *kbq* U_{235} *eq*) primarily due to high energy consumption (56,389 *kbq* U_{235} *eq*) followed by pre-settler process of the water treatment plant (Fig. 6). However, due to chemical consumption, ultrafiltration process that uses hypochlorite emits the maximum amount of ionizing radiation (7,200 *kbq* U_{235} *eq*) in its life cycle (cradle to grave) when compared to all the other chemicals used in the plant.

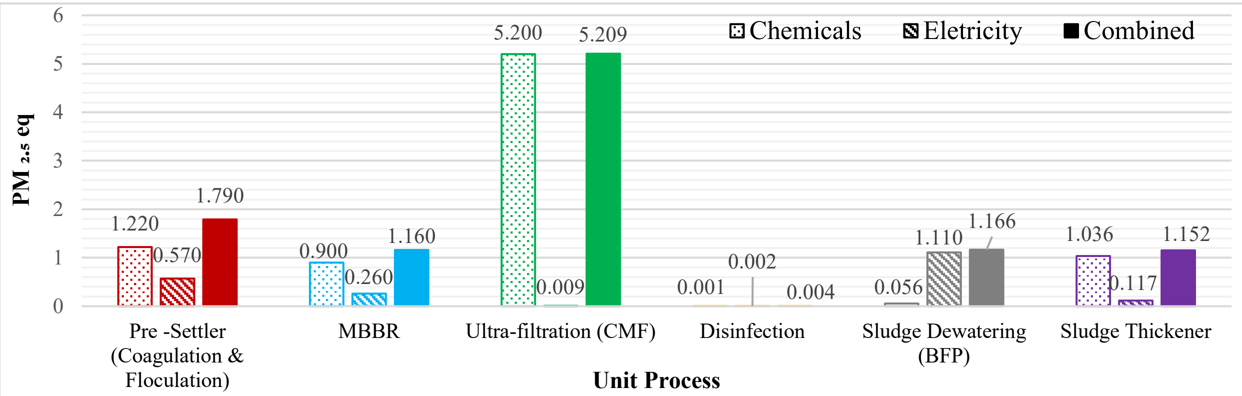

Fig. 5: Respiratory inorganics potential of unit processes.

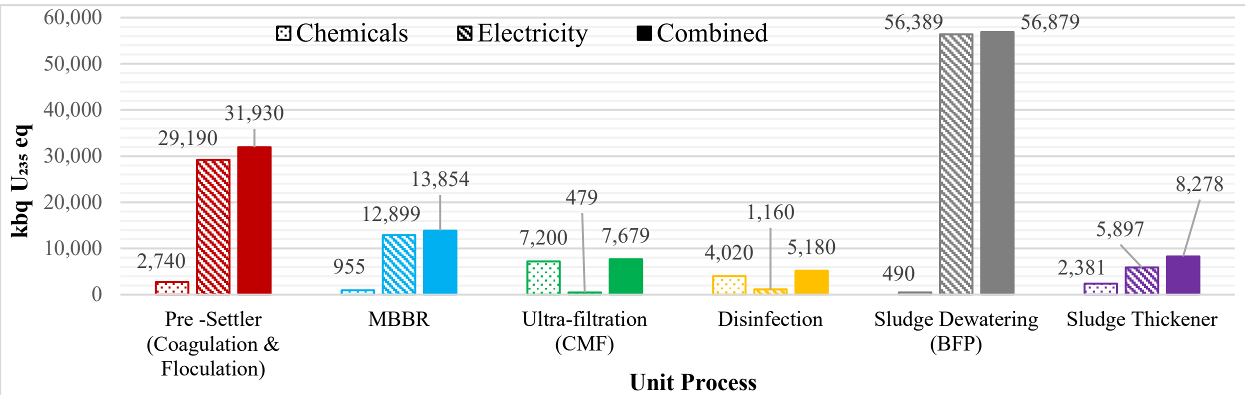

Fig. 6: Ionizing radiation potential of unit processes.

4.6 Ozone depletion potential (ODP)

The ODP of a chemical is a measure of how much harm it may do to the stratospheric ozone layer[31)] when compared to an equivalent quantity of trichlorofluoromethane (CFC-11).

Fig. 7 shows that the pre-settler and sludge thickening processes have a high ODP of 0.93×10^{-7} and 0.84×10^{-7} *kg CFC-11 eq* respectively due to chemical consumption among all the water treatment processes. Both these processes use PAC and poly anion. The slight difference in the value of ODP for these two processes is possibly due to the amount of PAC dose – 30 *ppm* dose for flocculation in the pre-settler process and 25 *ppm* dose in sludge thickening process. The results also indicated towards higher ODP of PAC than poly anion. Due to energy consumption, the pre-settler process has the highest ODP (0.59×10^{-7} *kg CFC-11 eq*) followed by sludge dewatering process (0.11×10^{-7} *kg CFC-11 eq*). Overall, the pre-settler process has the highest combined ODP (1.52×10^{-7} *kg CFC-11 eq*) followed by sludge thickening process (0.85×10^{-7} *kg CFC-11 eq*).

4.7 Eco-toxicity (ET)

This environmental indicator represents the toxic impacts on an ecosystem that have the potential to damage individual species as well as the overall functioning and sustainability of the ecosystem. The ET potential is represented in Comparative Toxic Unit for ecosystems (*CTUe*) which is based on USEtox model.

Fig. 8 reveals that ET potential is more from energy consumption than chemical consumption (except ultrafiltration and disinfection processes due to low electricity requirements). The sludge dewatering process showed highest ET potential (chemicals: 68,741; energy: 4,83,336 and combined 5,52,077 *CTUe*) followed by pre-settler and MBBR processes mainly due to electricity consumption. Due to chemical consumption, the ET potential has been higher for sludge dewatering and ultra-filtration. However, the foremost reason behind the impact due to ecotoxicity is the use of electricity in the plant.

4.8 Terrestrial acidification (TA)

It is defined by changes in soil chemical characteristics. It is caused by the deposition of acidifying nutrients, such as nitrogen and sulphur. The environmental impact of oxides of nitrogen (NO_x), ammonia (NH_3), and sulphur dioxide (SO_2) has been examined under TA potential. It is expressed in *kg* CO_2 *eq*.

It can be seen from Fig. 9 that the pre-settler and sludge thickening processes have highest TA potential of $7{,}980\times10^3$ and $7{,}026\times10^3$ *kg* CO_2 *eq* respectively due to chemical consumption. The high impact has been due to the consumption of PAC and poly anion in these processes. The slight difference in the value of the impact in these two processes may be attributed to difference in dosing. However, due to electricity consumption, the sludge dewatering process has the highest impact ($5{,}097\times10^3$ *kg* CO_2 *eq*) followed by pre-settler process ($2{,}638\times10^3$ *kg* CO_2 *eq*). Overall, the pre-settler process has the highest TA potential ($10{,}618\times10^3$ *kg* CO_2 *eq*) followed by sludge thickener process ($7{,}559\times10^3$ *kg* CO_2 *eq*).

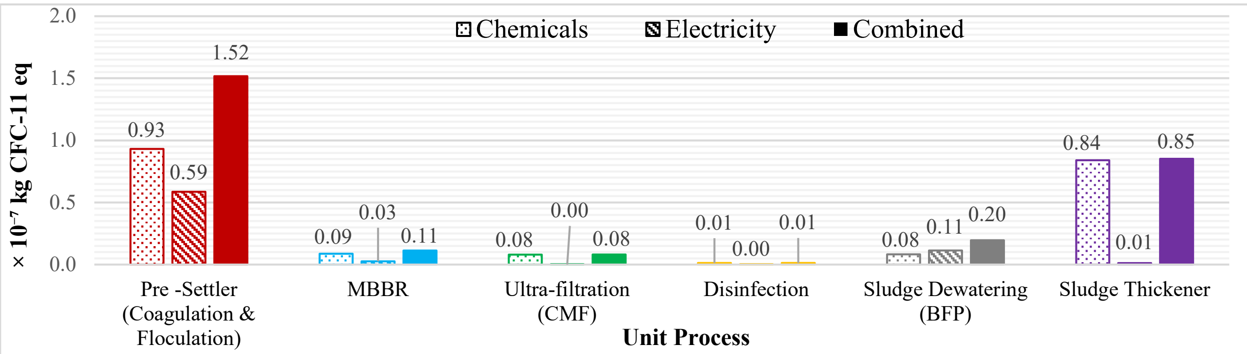

Fig. 7: Ozone depletion potential of unit processes.

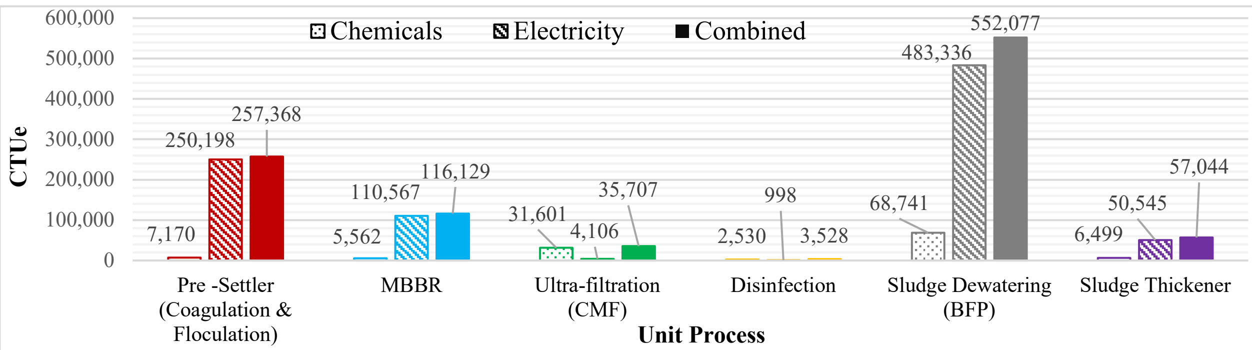

Fig. 8: Eco-toxicity potential of unit processes.

4.9 Water scarcity (WS)

This environmental impact category considers the local availability or scarcity of water in the areas where the activity actually takes place. The impact is influenced by withdrawal of water from raw water sources, such as rivers, streams, lakes, reservoirs, or groundwater. The potential impact due to WS is generally represented in cubic meters (m^3) of water-use related to the local water scarcity. Fig. 10 shows the water scarcity potential due to different water treatment processes.

The major contributor to WS potential due to chemical consumption are pre-settler (145.00×10^3 m^3eq), MBBR (85.29×10^3 m^3eq), and sludge thickener (20.42×10^3 m^3eq). The results revealed that PAC, poly anion and phosphoric acid contribute maximum to water scarcity as compared to other chemicals used in the water treatment plant.

Due to energy consumption, the WS potential has been even higher than chemical consumption as the production of electricity consumes a lot of water. As a result, the sludge dewatering process, which consumes the highest amount of electricity, has the highest WS potential in terms of combined (553.93×10^3 m^3eq) as well as due to electricity consumption (553.15×10^3 m^3eq) as shown in Fig. 10.

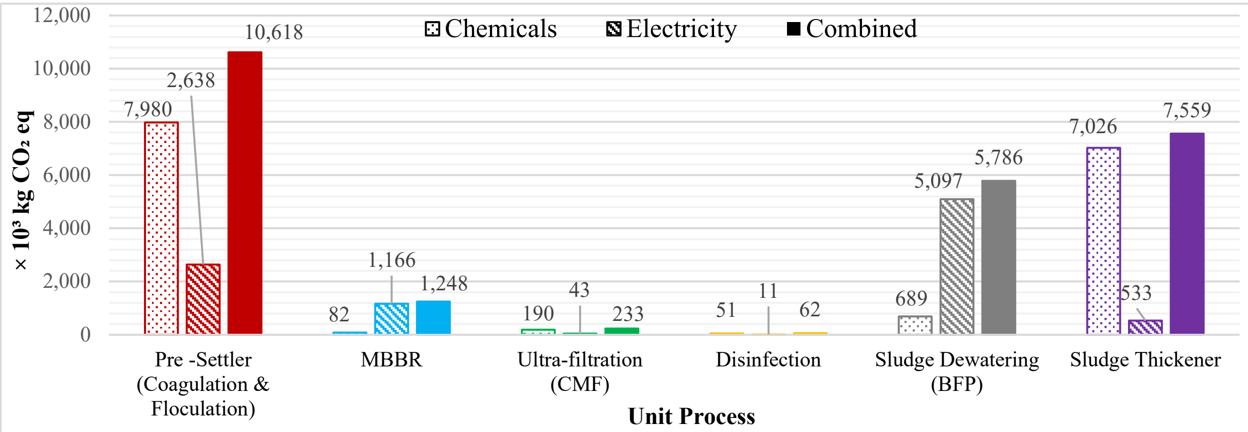

Fig. 9: Terrestrial acidification potential of unit processes.

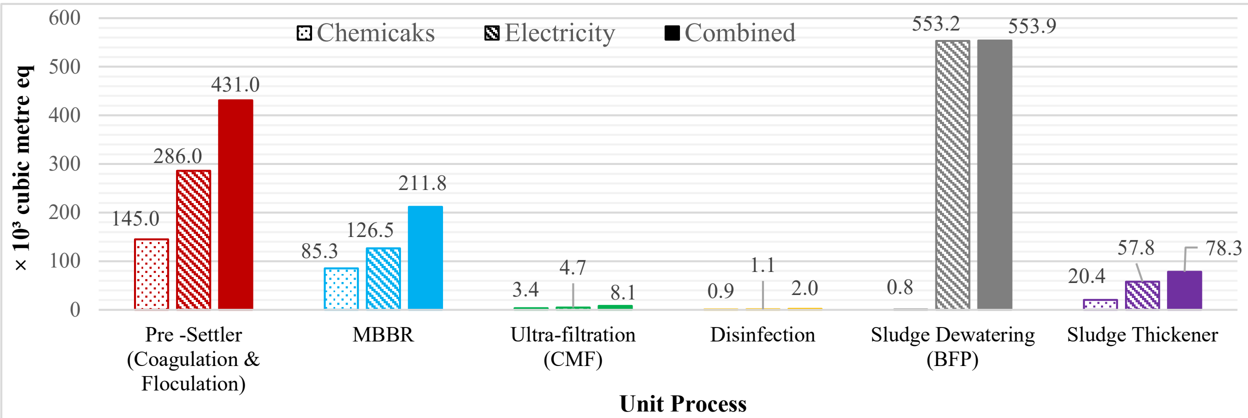

Fig. 10: Water scarcity potential of unit processes.

5. Conclusions

Based on the results and discussion of environmental evaluation or LCA of water treatment plant based on non-conventional MBBR process for the purpose of production of drinking water for public water supply, the following conclusions have been made:

- In the impact area of climate change, the major contributors to impact AP and GWP indicators have been the unit processes of sludge dewatering, pre-settler and MBBR processes.
- The major contributors to impact AP, RI, HT, ODP and IR categories in the impact area of human health have been the unit processes of sludge dewatering, pre-settler, MBBR, ultra-filtration and sludge thickening.
- The unit processes of pre-settler, sludge thickening and sludge dewatering processes have been the major contributors to impact ET, TA and ODP indicators in the impact area of ecosystem quality.
- In the impact area of resource depletion, the major contributors to impact WS indicator have been the unit processes of sludge dewatering, pre-settler and MBBR.
- Electricity consumption primarily contributes to environmental impacts from the water treatment process in terms of all the studied impact indicators (categories); except TA, ODP and GWP impact indicators wherein the chemical consumption contribution predominates.

In view of the above, the environmental impacts from the water treatment plant could be mitigated or at least reduced by the usage of green electricity generated from renewable resources, and alternate chemicals with fewer impact potentials wherever possible to offset environmental concerns. Further, the impact can also be lowered by using highly efficient equipment and their proper maintenance, and plugging the wastages and/or leakages of chemicals. The research in the areas of eco-friendly treatment processes, chemicals and integration of in-house green energy source needs to be focused and encouraged.

The systematic environmental evaluation of water treatment plant for the public water supply using LCA tool presented in this paper could serve as a prerequisite step in water management policy- and decision-making consistent with the SDGs.

Acknowledgements

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Nomenclature

BOD	Bio-chemical Oxygen Demand
COD	Chemical Oxygen Demand
CTUe	Comparative Toxic Unit for ecosystems
CTUh	Comparative Toxic Unit for Humans
DO	Dissolved Oxygen
eq	equivalent
kbq	kilo bequerels
kWh	kilowatt hour
mg/L	milligrams per litre
MLD	Million litres per day
MPN/100 ml	Most Probable Number per 100 millilitres
NTU	Nephelometric Turbidity Unit
ppm	parts per million
TSS	Total Suspended Solids

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