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SEWAGE TREATMENT AND REUSE FOR URBAN APPLICATION TO ADDRESS THE CHALLENGE OF CLIMATE CHANGE IN MEGA CITY OF LAHORE

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Abstract:

Pakistan is facing the water deficit because the ground and surface resources of water have depleted, storage capacity has been lost, droughts, increased water demand for domestic and industrial purposes. The water availability has been lessened 1000 cubic meter in 2020. Estimates show that the decrease will be up to 700 m^3 per cap., much less than the per capita international standard of 1500 m3. Ravi River flowing through Lahore city is polluted. The wastewater has used as oxidation ponds for fish production irrigation purposes. Wastewater from household and industrial sources had added Ravi via 2 surface drains and 5 outfalls located between the 98 km long stretch of Balloki Headworks and Ravi Siphon. It has been estimated that around 4,847,040 m^3/day of waste water is received by the Ravi. The main obstacles in the waste water treatment are operational and capital costs, process intricacy, and energy intensive traditional treatment technologies. Therefore, a low cost treatment strategy for waste water is required for Lahore. This paper discusses effective and feasible sewage treatment technologies for mega city of Lahore.

Key words: Sewage treatment, Climate Change, Activated Sludge, Urban Application

Terminology:

TSS:	Total Suspended Solids
BOD:	Biological Oxygen Demand
COD:	Chemical Oxygen Demand
WWTP:	Waste Water Treatment Plant

1. Introduction:

World's urban population is increasing at an increasing rate. As the living standards of the people is improving, large amounts of fresh water are used for domestic, commercial and industrial purposes which generates a huge volume of wastewater (Lazarova and Bahri, 2005; Qadir et al., 2007a; Asano et al., 2007). This water is released in natural water streams without any proper treatment. This practice is polluting the remaining fresh water resources and then it is resulting in severe shortage of water in most of the countries (Keraita and Drechsel, 2004; Scott et al., 2004). This practice causes waterborne diseases due to the pathogens, heavy metals and other undesirable constituents depending on the source for the farmers who are in contact with that water

and for the consumers also (Qadir et al., 2007a; Azizullah et al., 2010). Thus, it is imperative to explore other sources of water such as wastewater, to meet the increased demand.

Statistical researches have shown that Indus River along with its tributaries deliver 142 MAF water, of which 96 MAF, 36 MAF and 10 MAF is supplied for irrigation, seas flow and system losses – seepage, evaporation, and spill, respectively. Currently, 40.5 MAF water is pumped out annually, of which 36% is highly-saline and 60-80% is saline. Governmental data shows that 88% of urban population, as well as 62% of the rural population have direct access to water supply. However, 33% of people in Pakistan do not have direct access to potable water, and 67% people are dependent upon nearby filtration facilities. A study on the analysis of water quality revealed that 55% water samples collected at different sources were contaminated with coliform bacteria (Z.A. Bhatti, 2009).

Around three out of 100 industries in Lahore district treat their effluent containing hazardous chemicals, while all others discharge the effluent into river. Expansion of a metropolitan city such as Lahore can continue to increase the problem in future (Z.A. Bhatti, 2009). Sewage water in urban areas mainly consists of effluents from domestic and industrial sources, deposition from the atmosphere and the pollutants associated with transport such as oil leakage, brake linings, etc. Only about 20-25% of pumped water is used in Lahore, while remaining flows off into the sewage system. The drainage system comprises of eight main drains and 75 sub-drains that transport 7474 Cu of water. All of the water from these drains is transferred into the Ravi river (S. Majeed, 2018).

2. SEWAGE TREATMENT:

Sewage treatment involves removal of contaminants from household sewage and runoff waste water. The processes involved in treatment are physical, chemical and biological. The aim of this treatment is to treat the effluent that can be safely discharged into the environment. Sewage must be treated at the point of source of generation using septic tanks, aerobic treatment, and bio-filters (Z.A. Bhatti, 2009). Sewage Treatment can be carried out by following means:

2.1. Mechanical Treatment:

Preliminary Treatment is used to eliminate material that can easily be removed from raw waste water. This treatment prevents clogging of pipes and pumps of the next stage treatment system (Z.A. Bhatti, 2009). Pre-treatment is carried out in various steps. Firstly, Incoming waste water is screened off to remove the debris material from waster such as fruit peels, rags, cans, sticks, etc. Screening is carried out using fine or coarsely spaced bar screens that are cleaned mechanically in large treatment facilities while small treatment plants utilize manually cleaned bar screens (Z.A. Bhatti, 2009).Grit removing tank also regarded as the de-gritter. The velocity of influent is maintained to allow settlement of the stones, grit, and sand particles, while most of the suspended matter remains in the water stream. The removed matter can be incinerated but in majority of the processes it is disposed into a landfill (Z.A. Bhatti, 2009). Primary Sedimentation involves primary clarifiers or sedimentation tanks. Sewage water flows through these tanks that are large enough to promote settling of suspended matter while

the floating material increases to the top to be skimmed off. Sedimentation is aimed to generate a homogenous liquid that is adept to be biologically treated, whereas the sedimented material is separated. Sedimentation tanks comprise mechanical scrappers that remove the collected sludge that is treated separately into the sludge treatment process (Z.A. Bhatti, 2009). The objective of the secondary treatment is to remove biological contaminants – human and food waste, detergents, soap, etc. from sewage. Waste water treatment is carried-out by aerobic treatment. This requires microbes and sufficient oxygen supply to consume the pollution.

2.2. Biological wastewater treatment systems

In biological wastewater treatment systems, bacteria and other microorganisms are used to remove excess nutrients and contaminants. These systems are effective, consume less energy and more environmentally friendly. Many biological systems are available these days and are widely used. But not all the systems are of same type and value. So, choosing the best suitable treatment system according to temperature, efficiency and cost is not easy.

2.2.1. Activated sludge

Activated Sludge is biological treatment plant designed to remove organic matter from wastewater by converting it into carbon dioxide, water and other inorganic compounds. In this process, growth reactor is an aeration tank or basin where microorganisms are kept in suspension and in contact with wastewater to be treated as shown in Figure 1. The contents of the aeration tank are mixed vigorously by aerators which supply oxygen to the biological suspension (Henze et al., 2001; Arceivala, 2006). The BOD removal efficiency is about 75 to 85 percent. The secondary treatment facility is based on type of biomass found in waste water.

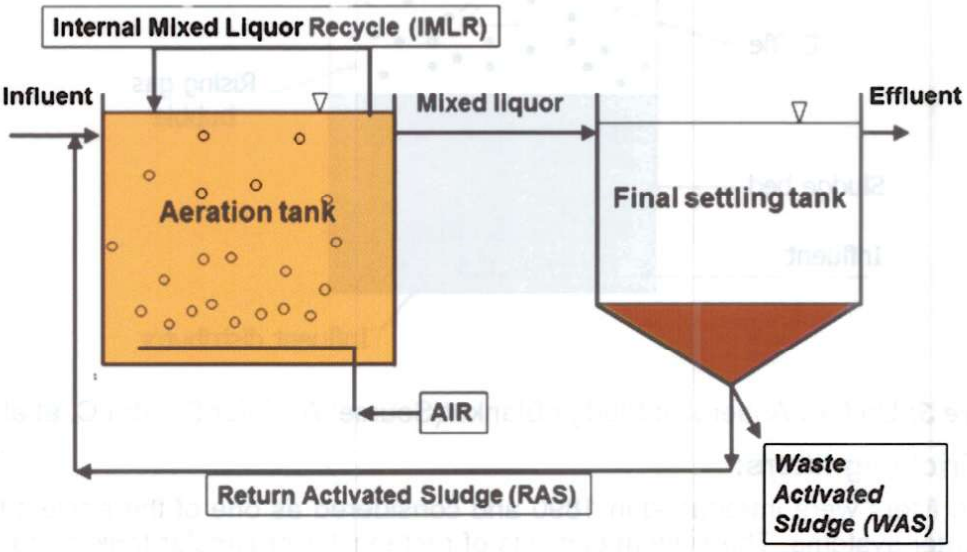


Figure 2: Activated Sludge Process (Source: ysi.com Rob Smith 2016)

This process has shown 88% removal efficiency of COD and 92% of BOD and about 93% to 99% removal of nitrogen (Vaiopoulou et al., 2007). An estimated 1 kg of BOD

which is removed in an activated sludge process requires one kWh of electricity for aeration, which produces one kg of fossil CO_2 from power generation. This CO_2 is a greenhouse gas which is one of the greenhouse gases (Talbot *et al.,* 1993; Jenkins et al., 2004).

2.2.2.Upflow anaerobic sludge blanket

The UASB reactor is considered desirable in high strength organic wastewater treatment because of its high biomass concentration and rich microbial diversity. These reactors are the most flourishing technology and appear as well performed technology from many decades. It has an affinity for BOD and intestine nematode but the suspended and colloidal solids present in the wastewater halt the system from operating at increased organic loading rate (OLR), which can in turn cause the deterioration of microbial activity and destroy active biomass (Torkian *et al.*, 2003). UASB reactors can be efficiently applied for the pre-treatment of municipal wastewater at low temperatures but it requires post-treatment for the removal of COD, TSS, ammonia and pathogens (Tawfik *et al.*, 2002). The size of granules is about 1-3 mm diameter. Since granules are bigger in size and heavier, they will settle down and retain within the reactor. The concentration of biomass in the reactor may become as high as 50 g/L. Thus a very high Solid Retention Time can be achieved even at very low Hydraulic Retention Time of 4 hours as shown in Figure 2.

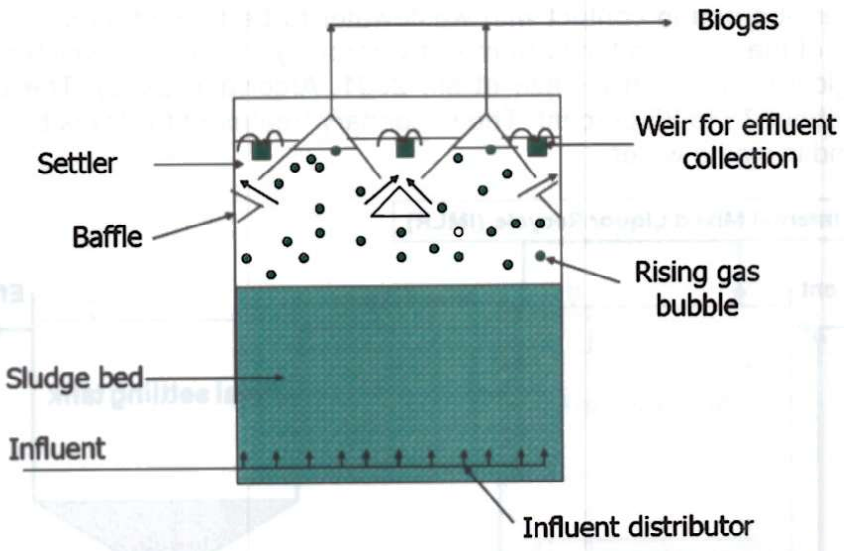


Figure 3: Up flow Anaerobic Sludge Blanket(Source: Anijiofor Sandra C. et al. 2017)

2.2.3 Trickling filters:

Trickling filters were introduced in 1890 and considered as one of the earliest biological wastewater systems. The system consists of rectangular or circular tank containing filter medium with a depth of approximately 1-2.5m. The filter medium is usually stones, ceramic material, treated wood, hard coal or plastic shapes. About 85% BOD is removed by this system. This system is efficient in areas where there is larger area available for

circular ponds. It is relatively cheap, easy to handle and reliable way of treatment (Henze et al., 2001; Bitton, 2014).

2.2.4. Membrane bioreactors:

These systems consist of combined activated sludge system along with the membrane liquid separation system. The membrane liquid separation systems utilize ultra-filtration membranes or low pressure microfiltration systems that does not require tertiary filtration and clarification. Hence, the higher retention time for sludge that is often more than 15 days and allows thorough nitrification of sludge even at low temperatures. However, the capital and operational costs of membrane bioreactors is higher than the conventional sludge treatment systems (Z.A. Bhatti, 2009).

2.2.5. Rotating biological contactor

Rotating biological contactor (RBC) is a fixed film reactor in which wastewater is treated using microorganism membranes attached to the disks which slowly rotate by an electric motor. Approximately 40% of surface area of the disks is submerged in wastewater (Tawfik *et al.*, 2002). (Urkiaga *et al.*, 2008; Henze, 2002). In this process, organic leading rate should be compatible with amount of oxygen provided to the biofilms to avoid odors and reduced efficiency of the system. This system has low energy requirements; works well in less retention time and has low operational control as compared to trickling filters (Vesilind, 2003).

2.2.6. Wastewater stabilization ponds:

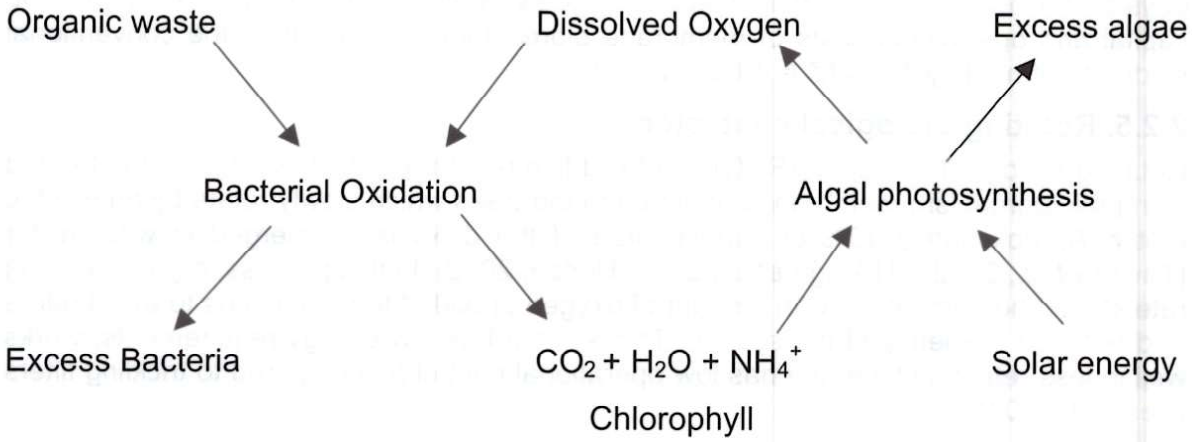
Wastewater stabilization pond (WWSP) system is considered as one of the simplest way of wastewater treatment. These are shallow ponds used to treat domestic and industrial wastewater. It is more favorable in warm climate countries with high temperature and sunlight, like Pakistan (Sperling, 2007). Stabilization ponds are feasible for developing countries because of their low operational and maintenance costs, robustness, greater contaminants removal efficiency, lower energy needs, and better water reuse potential. These ponds are environmentally sustainable, have greater life spans as compared to the conventional treatment facilities and provide source of irrigation for nearby public parks and ponds (Woltersdorf L., 2018).

2.2.7. Oxidation ponds:

The problems associated with all above biological treatment systems can be resolved by growing algae in the ponds and tanks where wastewater treatment is carried out. The main purpose of these ponds is to increase algal biomass and photosynthesis which will increase the level of oxygen creating aerobic conditions throughout the pond (Oswald, 1988). Oxidation ponds may be aerobic, anaerobic, maturation, and facultative ponds. Aerobic Ponds have high photosynthetic activity rate of algae at 30-45cm depth. These ponds have BOD removal efficiency of 95%. Anaerobic Ponds are 1-2 m deep, having very low amount of dissolved oxygen, acidic pH (less than 6) and temperature more than 15°C. These ponds have 60% removal efficiency of BOD. Maturation ponds are 1m to1.5m deep and remove nutrient, pathogens and coliform along with the waste water treatment. Facultative ponds are surface divided ponds that maintain both the anaerobic and aerobic conditions. These are 1-2m deep and have 95% BOD removal efficiency (Butler E., 2017).

2.2.7.1. Process involved in algal ponds

In oxidation ponds, algae have a beneficial relationship with aerobic bacteria. It utilizes the sunlight and provides oxygen to aerobic bacteria to biodegrade the organic contaminants of wastewater through photosynthesis. Bacteria utilize this oxygen and release nutrients as nitrogen and phosphorous which are consumed by the algae (Shi et al., 2007).



It also removes pathogens, organic contaminants and heavy metals from the domestic wastewater (Luz et al., 2011). The algal biomass produced from the treatment can be harvested and then could be converted through various methods to biofuels like biogas, biodiesel, bioethanol and bio-crude oil (Mata et al., 2010).During the treatment process, carbon dioxide uptake by algae was measured and concluded that the process is a net carbon dioxide fixer (Reith *et al.,* 2014). It also removes heavy metals and pathogens from the wastewater. A pH of 9.2 for 24 hours provides a 100% kill of E.coli and most pathogenic bacteria and viruses (Rose et al., 1996).

Different studies have shown that different types of algae have different tendencies for the removal of nutrients from the wastewater. Three algae, *Chlorella vulgaris, Scenedesmus rubescens* and *Stigeoclonium stagnatile* helped to remove more than 90% phosphorous from the sewage in oxidation ponds in the time of about 6-12 hours. *Chlorella vulgaris*, a microalgae, removed 75% ammonium, 6% nitrate and 19% phosphorus while co-immobilization of *Chlorella vulgaris* and *A.brasilense* removed 100% ammonium, 15% nitrate and 36% phosphorous within 6 days of treatment (Luz et al., 2004) *Gracilaria birdiae*, a macroalgae, reduced the amount of the nutrients e.g., PO_4^{3-} by 93.5%, NH_4^+ by 34% and NO_3^- by 100% from aquaculture wastewater over the period of about 4 weeks (Marinho et al., 2009).

Algae based wastewater treatment system in oxidation ponds is a cost effective way of treatment. It has a low energy cost, lower operation costs and in the end, algae biomass can be used for the production of biofuels (Ogbonna et al., 2012). High operation costs make wastewater treatment conventionally unviable in many countries (Groenlund et al., 2004).

2.3. Lagooning:

Lagoons may be single or multi cellular designed reservoirs for the treatment of wastewater that dilute the organic pollution in water using bacteria. The oxygen and air requirement of lagoons depends upon the nature of bacteria present in reservoirs for waste degradation. These characteristics make lagoons different from the oxidation ponds. Lagooning provides settlement and further biological improvement through storage in large man-made ponds or lagoons. These lagoons are highly aerobic and colonization by native macrophytes, especially reeds, is often encouraged. Small filter-feeding invertebrates, such as Daphnia and species of Rotifer, greatly assist the treatment by removing fine particulates (Z.A. Bhatti, 2009).

2.4. Constructed Wetlands:

Constructed wetlands include engineered reed-beds and a range of similar methodologies, all of which provide a high degree of aerobic biological improvement and can often be used instead of secondary treatment for small communities. Constructed wetland is fed in at the inlet and moved in laminar regime through porous medium, until it reaches the outlet zone where it is collected before the outlet. Constructed wetlands have long been used for domestic and municipal wastewater (Z.A. Bhatti, 2009). A local plant, Reed (Phragmites) was evaluated (using a lab scale wetland model) for its potential use in constructed wetland. Removal efficiency of the system was evaluated at different detention times ranging from 1 to -5 days. The results demonstrated 90% removal for TSS, 75% removal for BOD and 80% removal for COD at 5 days detention time. The mean effluent concentration of 10 mg/L, 40 mg/L and 68 mg/L for TSS, BOD, and COD, respectively was obtained at 5-days detention period, thus complying with effluent standards of Pakistan. The results of the study support the suitability of Constructed Wetlands for Lahore, and also motivate for detailed pilot plant studies.

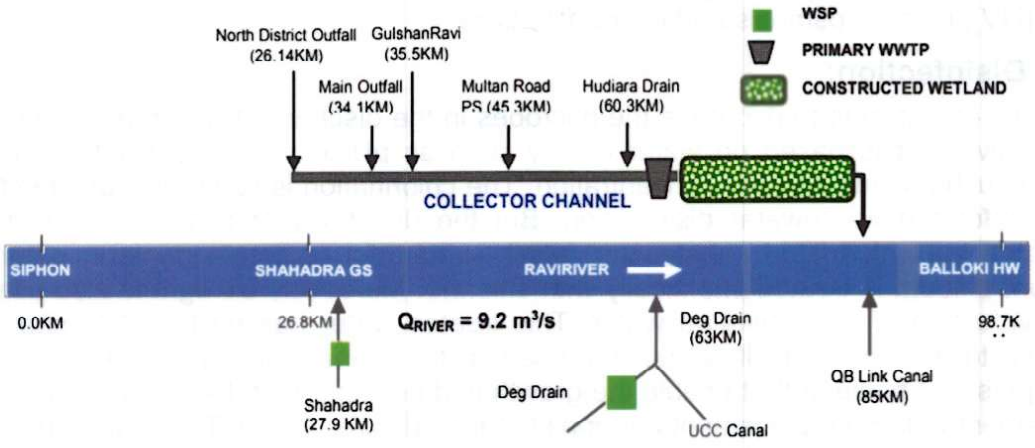


Figure 4: wastewater reuse and treatment design for Lahore sewage (Source: Haider et al., 2015)

2.5. Nutrients Removal:

Nitrogen and Phosphorus are considered as major nutrients in wastewater. A huge amount of these nutrients accumulates in the wastewater, process known to be as eutrophication. It encourages the excessive growth of algae, cyanobacteria, and weeds. Bacterial decomposition utilizes oxygen by algae or other microbes and produces the organic matter (Kargi and Uygur, 2003). Nutrients are removed through domestic wastewater by Sequential-batch, which is effective to reduce Total Suspended Solids (TSS), Nitrogen in ammonia and BOD of about 90,89 and 98 percent for 12 hrs. (Malik et al. 2017).

2.5.1. Nitrogen Removal:

Biological oxidation occurs when ammonia is converted into nitrate and then into nitrogen N_2 gas through microbial facilitated denitrification process. In addition, N_2 is entered into atmosphere and also eliminated from water (Verstraete, 2004). Nitrogen is reduced by lagoon process, reef beds and also sand filters. It can be readily done through activated sludge and membrane aerated biofilm reactor.

2.5.2. Removal of Phosphorus:

Phosphorus is used as limiting element for the growth of algae in surface water. It is significant for reuse of water treatment system like Reverse Osmosis plant (Landner, 1976). Biological pumps are used to remove the phosphorus with particular bacterial specie such as polyphosphate accumulating organisms, which are enriched and removed it in cells. As a result, the value of fertilizer is high in bio-solids (Verstraete, 2004).

2.6. Tertiary Treatment:

Tertiary treatment process aims to increase quality of effluent when it discharges into environment. Effluent polishing occurs that includes ozonation, treatment through Ultra Violet (UV), reverse osmosis and micro- filtration.

2.6.1. Disinfection:

The main objective is to decrease the microbes in the discharged water in environment. Its effectiveness is based on water quality such as pH, cloudiness, disinfection type, dosage such as time and the concentration. The chlorination is commonly used in North America for the wastewater disinfection. But the drawback of this process is that it generates the chlorinated substances, which is harmful or carcinogenic in nature. In addition, effluent is treated chemically with chlorine. Moreover, UV light is also used for the disinfection of contaminated water. This treated water has no harmful impacts on humans to consume it. It actually damages the genetic composition of viruses, pathogens and bacteria that enable the growth and development. Its disadvantage is the requirement of lamp replacement and maintenance (IBWA, 1995). The oxygen molecule is passed in great voltage that generates the other oxygen atom and produce the ozone O_3. It is reactive, unstable and also oxidizes the organic substances to destroy harmful microbes. It is quite safer as compared to chlorine that is capture outside. Ozonation makes by-products that cause less disinfection. Apart of benefits, it has some drawbacks that include huge cost of equipment and need for operators.

3. Reuse of wastewater

The growing urbanization in many countries has not only increased water demand per capita but also resulted in significant increase of urban wastewater. Water issues including excessive water depletion, water quality deterioration, water logging, and salinity are the major factors which are a major cause of increasing trend of reusing wastewater for different purposes (Amahmid et al., 2002). Municipal wastewater represent a valuable source of water and nutrients which can be reused for landscape irrigation in parks, school yards, golf courses, cemeteries, greenbelts and residential uses. About 70% of the freshwater available is utilized for agriculture globally (Urkiaga et al., 2008).

3.1. Wastewater recycling options

A list of the options for wastewater reuse includes:

- Agricultural irrigation: crop irrigation, commercial nurseries
- Landscape irrigation: parks, gardens, green-belts, golf courses, football fields and highway landscaping, school yards, cemeteries
- Recreational/environmental uses: Lakes and ponds, snowmaking
- Aquaculture and fish farming
- Ground water recharge
- Aquifer recharge for the prevention of saline water intrusion
- Non potable urban uses: fire protection, roads washing, toilet flushing.
- Industrial uses: cooling, boiler feed, process water (Urkiagaet al., 2008).

Reusing wastewater for agricultural and landscape irrigation is an opportunity that can potentially reduce the use of canal water for irrigation and helps to save the remaining fresh water resources (Murray and Ray, 2010).

Table 1: the wastewater discharges in Ravi River for 2034

No.	Wastewater Outfalls/ Surface Drains	BOD (mg/L)	Flow (m^3/s)	BOD Weighted average (mg/L)
LEFT BANK				
1.	NE District Outfall	240	13.3	
2.	Main Outfall	198	7.8	
3.	Gulshan Ravi Outfall	246	6.4	245
4.	Multan Road Outfall	234	4.1	
5.	Hudiara Drain	270	18.8	
	Total		**50.4**	
RIGHT BANK				
6.	Shahadra Outfall	465	2.7	
7.	Deg Drain	379	9.3	
	Total		**62.4**	

3.2. Fertilizers:

Farm manure is considered as principal component used from the farmers for the improvement of soil fertility and increasing physiochemical parameter of the soil .It is costly and deficient; so, bio-waste resource like domestic waste and urban sewage which are considered as alternative measure for recycling and enhancing the quality of soil. The application of rational land enhances fertility of soil, crop yield and biological actions.

Agriculture receives about 67% of total water withdrawal and accounts for 86% of consumption in 2000. Water requirement for agriculture is expected to be increased by 1.2 times till 2025. It is important to reuse wastewater for agriculture to manage present water resources sustainably (UNESCO, 2000).Wastewater reuse for agriculture will help to conserve freshwater resources and their wise use particularly in areas under water stress (Mara, 1989).

3.3. Reclamation of the degrade soils:

Domestic sewage and ash from coal and biomass contain greater nutrient level and can be utilized in the manufacture of biomass and reclamation of the degraded sites(Sajwan et al. 1995).Because of enhanced waste, the sludge and ash are used as considerable source of the nutrients (Shaheen et al., 2014). It is highlighted that the availability of P, Mg, N, Ca and K varied with different concentrations. It increased the plant development and yield growth at the rate of 247 Mg per hectare that results the reduction of biomass in plants. It was tested the sludge mixtures through ash at the rate of 0 to 50 percent (Su and Wong 2016; Antonkiewicz et al., 2020)

4. Reuse of treated wastewater for landscaping

In urban areas wastewater reuse for landscaping is of much importance. Landscape irrigation includes the irrigation of parks, play grounds, golf courses, school and residential yards and green belts. Landscapes around commercial areas, offices, industries and residences can be irrigated with this water (Urkiaga, 2008). Wastewater can also be used for recreational purposes e.g. development of recreational lakes, man-made lakes, golf course storage ponds, marshes, streams and for commercial nurseries. Aquaculture and fish farming is a growing industry in Pakistan contributing about 1% to the GDP of Pakistan (Metcalf and Eddy, 2003; Urkiagaet al., 2008).

Water scarcity and the contaminated water irrigation are managed through the reuse of water. Global practice for irrigation of landscape and agriculture is related to reduce water and also to solve the issue of disposal of polluted water. In many urban sites, the reuse of contaminated water is practically used; so, it does not require high quality. The irrigation of landscape includes the irrigation of golf courses, play-ground, schools and parks and green belts. Fish farming as well as aquaculture are the most growing sector that contributes 1 percent to GDP in Pakistan. This water is used for the culture of fisheries that facilitates to improve the growth in water scarce zones. Cost of the pumping of water for the irrigation of landscape in the parks of Lahore could be managed by using this polluted water. While, the collection of the wastewater cost is quite low because many drains are passing very near to the parks .Furthermore, the fertilizers' cost is also minimized through water reuse for the landscaping purposes.

Also, the fresh water is utilized for the purpose of drinking in the communities at which no pure water is accessible. This research can apply to main parks in Lahore for checking the effectiveness of this whole system for saving energy cost and use of fresh water. This can initiate with ponds construction and huge shallow ponds for proper implementation in field (Yasar et al. 2015).

The advantage of using wastewater for landscaping is the increased availability of water for the management of parks and recreational areas which will help to increase the aesthetic beauty of the city and to maintain its greenery. The artificial ponds and lakes supplied with reclaimed water will be beneficial for the growth of aquatic life such as fish, insects, crawfish and shellfish. Different reuse options will play a significant role in controlling water consumption and reducing its pollutant load on the environment (UNEP Report).

The issue of concern for wastewater reuse is the water quality and the cost and efficiency of wastewater treatment methodology to be used. Health and environmental aspects are of utmost importance when planning to reuse wastewater for agriculture and landscaping. Landscape plants grow faster with reclaimed water but it should be clear, colorless, odorless and free from microorganisms. So in addition to secondary treatment of wastewater, filtration and disinfection are generally required for its reuse (Urkiagaet al., 2008; Pedrero et al., 2010).

5. Climate change challenges on Water reuse:

Recently, this sector is at turning point. The water demand and supply are affected through technology, variation in policy and growth in population and also droughts. These variations in the climate will highlight the current challenges and carry the innovative risks. Actually, the direct effects are referred to the impact on the factors of climate on the performance of technology (O'Neill, 2010). Whereas, the other are indirect impacts that involves with activities of operation and maintenance like activities such as water use control and greenhouse gas emissions like CO_2, N_2O, CH_4 etc. The sector must address three linked challenges:

- Improvement of the quality of water
- Creation of smart investment of re-use and recycles water
- Maintenance the different issues of watershed
- Enhance the vulnerability of wastewater treatment process

6.1. Adaptation measures:

Principally, certain adaptive measures are involved upgradation, installing different structures in treatment and water reuse for the operation and maintenance the system (NACWA, 2009). It is classified into 4 groups with different factors. The infrastructure should be as safe for great regime of precipitation to minimize the rate of run-off in the main sewage pipelines. Similarly, this green infrastructure facilitates to remove the increasing temperature. The other factor in terms of measures was the mechanical cooling (Mailhot and Duchesne, 2010).

Table 2: Impacts and adaptation strategies for the wastewater reuse and treatment (NACWA 2009)

Factors	Adaptation strategies
Changes in precipitation quantity and timing	• Reduce infiltration and inflow into sewers, flow diversion • Green infrastructure to manage site run-off • Rapid treatment
Changes in maximum temperature and other environmental variables	• Wetland treatment • Riparian restoration • Mechanical cooling • Evaporative cooling • Blending with cooler waste streams
Increased sea level Increased flood events	• Installing levees and sea walls around WWTP and key infrastructures • Hardening sewer collection systems to reduce infiltration
Collaboration between supplied water and wastewater	• A new distribution infrastructure

WWTP (waste water treatment plant)

The main concern regarding the emergent issue of climate change is the replacement of existing systems and the new installations (Willems, 2013). Many developing nations have insufficient and inadequate systems for the collection of wastewater treatment. High income states treated the 80 percent of wastewater (Baum et al., 2013). The second challenge was the demonstration of the parameter of meteorological designs. Previously, the data was used to design the various systems to stabilize the life cycle. Finally, the issue was uncertainties of the future predictions (Major et al., 2011).

7. Conclusion:

Wastewater reuse and treatment is contributing major factor for alteration in the patterns of reuse, development in population, novel regulations and different climatic pressures in recent decades. This review sheds light on synthetic overview on the sewage treatment and reuse for the urban applications for addressing the climate change in the city of Lahore. Recycled and reuse of water is the primary necessity for every nation. Therefore, the chances and the risks from the climate change in the reclamation of water are merely interwoven. Although, it provides a superfluous market along willingness to reuse water but the main challenges are temperature, extreme weather events and precipitation. Different reforms include enhance the data sharing and association through local supplier as well as state agencies, smart systems of water reuse, planning for droughts, making the policies and tools for managing the main objectives in watershed that will better prepare the agencies to tolerate the effects of the reduction in water reuse in droughts.

In conclusion, it is reported that the aforementioned climate factors are main challenges for waste water treatment and reuse plants. It is demonstrated with the performance and absence of meteorological information at regular intervals. Consequently, certain

adaptive parameters have proposed to tackle the climate change effects on the treatment and reuse of system. In similar, adaptive measures such as control of water use, the emissions of greenhouse gases are addressed in this review paper. Other topics are recommended for the research in future:

- Effect on association of certain climate factors on reuse water schemes
- Multiple assessment on reuse systems with life cycle analysis and inventories
- GHGs emissions auditing by wastewater reuse treatment plant and it potential of generation by reuse.

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