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Review on Waste Water under Different Regions and Water Purification Techniques and Their Limitations

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Abstract

Wastewater refers to any water that has been used and discarded from various human activities, such as domestic, industrial, agricultural, or commercial processes. It contains a mixture of contaminants, including organic and inorganic substances, chemicals, pathogens, and suspended solids. Effective treatment and purification of wastewater are crucial to protect the environment and public health. Various wastewater treatment methods are employed to remove or reduce contaminants before the treated water is either released back into the environment or reused for non-potable purposes. Proper wastewater management is essential to prevent water pollution, conserve water resources, and ensure sustainable development. Wastewater purification is a critical process to mitigate environmental pollution and ensure water sustainability. This review explains the need of efficient wastewater treatment and purification methods to mitigate the adverse impacts of pollution on ecosystems and human well-being. Highlighting the importance of proper management, also role of technology, innovation, and policy in achieving sustainable wastewater solutions. As we navigate a world increasingly burdened by water scarcity and pollution, a holistic approach to wastewater emerges as a crucial endeavour for safeguarding our planet's precious water resources. Amidst global water challenges, a comprehensive approach to wastewater emerges as a fundamental step towards a healthier more resilient environment. Due to improper managing living things are facing to more serious health issues. All living things required water for drinking purpose but human beings need in a purified manner with reach minerals and salt. For the whole usefulness of drinking water, it should not be pure but also healthy. So Proper wastewater management is essential to prevent water pollution, conserve water resources, and ensure sustainable development. As there are lot techniques used for water purification such as Coagulation, Precipitation, Electrochemical, Advanced Oxidation Process, Chlorination, Flotation, Fenton method, etc. but due to their mass application, they have some limitations.

Keywords: Waste water, domestic, agriculture, pharmaceutical, industry.

1. Introduction

Wastewater is the term used to describe the water that has been used and contaminated during various human activities. It includes water from residential, commercial, industrial, and agricultural sources. After use, this water contains a range of pollutants, which can be physical, chemical, or biological in nature. Wastewater is a significant environmental concern because if not properly managed, it may pose critical dangerous risks to human fitness and the environment. More than 50% diseases are found to be waterborne as per national and international agencies in India due to wrong making plans in coping with sewage and irrigation waste waters emerge as a prime problem in latest years.**[1]** It is guesstimate from various countries that about 60% human deaths occur due to polluted water. Therefore, purification water is paramount importance. Removal of the hazardous chemical substances, dust, impurities etc. from the waste water is a good deal essential now not only for purification but also to store lots aquatic and human existence also, as it without delay or indirectly associated with food chain **[2].** When we use water for activities like washing, cooking, bathing, flushing toilets, or in industries for processes and cooling, it becomes wastewater. This water often carries a mix of organic matter, suspended solids, chemicals, nutrients, pathogens, and other pollutants. If released directly into the environment without treatment, wastewater can contaminate water bodies, leading to water pollution, negatively impacting aquatic existence, and making the water dangerous for intake or leisure use. Effective wastewater management is crucial for protecting public health, safeguarding ecosystems, and ensuring a sustainable supply of clean water for future generations. Water is one of the basic needs for all life. maximum of the herbal assets of drinking water are get contaminated due to toxic materials and pathogenic microorganism.**[**3**]** Due to continuous release of chemicals to the environment water is being get deteriorated. Thus, pesticides such as insecticides, herbicide. Fungicide is well known water pollutant. **[4-6]** According to WHO report about 12 million peoples die every year due to water borne diseases. **[7].** There are several methods of treating wastewater to remove or reduce its pollutants before it is safely discharged back into the environment. Common treatment processes involve physical, chemical, and biological treatment stages to remove contaminants and restore the water quality. Wastewater treatment facilities, commonly known as wastewater treatment plants (WWTPs), are responsible for treating large volumes of wastewater in urban areas. In some cases, decentralized or onsite treatment systems are used, especially in rural areas where centralized facilities may not be feasible. In recent years, there has been an increasing focus on wastewater reuse and recycling to address water scarcity challenges and promote a more sustainable approach to water management. Treated wastewater can be utilized for irrigation, industrial processes, and even indirect potable water supply in certain cases, following appropriate treatment and safety guidelines.

Sources of Waste Water

Water pollution can occur in various ways and from different regions due to human activities, natural processes, and industrial operations. Here are some common ways water gets polluted from different sources:

1. Commercial Discharges: Industries can release a wide variety of pollution into water our bodies. These may include toxic chemicals, heavy metals, oils, grease, and other harmful substances. Without proper treatment, industrial wastewater can find its way into nearby rivers, lakes, or oceans, polluting the water and harming aquatic life.

2. Agricultural Runoff: Immoderate use of fertilizers, pesticides, and herbicides in agriculture ends in runoff at some stage in rain events. These chemicals can seep into nearby water bodies, causing nutrient imbalances and harmful algal blooms. Additionally, livestock waste can also contaminate water sources if not properly managed.

3. Municipal Wastewater: Untreated or inadequately treated sewage and wastewater from cities and towns are often discharged into rivers and oceans. These discharges can carry pathogens, organic matter, and nutrients, leading to water quality degradation and posing health risks to humans and wildlife.

4. **Mining sports:** Mining operations can launch heavy metals, sediments, and acidic drainage into water our bodies, mainly throughout extraction and processing of minerals. This type of pollution can severely harm aquatic ecosystems and impact downstream communities.

5. Oil Spills: Accidental oil spills during transportation, offshore drilling, or tanker accidents can lead to massive contamination of water bodies. Oil spills will have devastating outcomes on marine life, coastal ecosystems, and nearby economies.

6 City Runoff: Stormwater runoff from city areas can pick out up pollution like oil, heavy metals, litter, and chemicals from roads, parking lots, and industrial sites. This polluted runoff often flows directly into nearby water bodies, contributing to water pollution.

7. Improper Waste Disposal: Unsuitable disposal of household and industrial waste can result in direct contamination of water assets. Dumping of garbage, plastics, and other non-biodegradable substances into rivers or lakes is a sizable situation.

8. Atmospheric Deposition: Airborne pollutants, together with sulphur dioxide and nitrogen oxides from business activities and car emissions, can be deposited into water bodies through precipitation (acid rain). This can lead to acidification of water and negatively impact aquatic life.

9. Agricultural Livestock Operations: focused Animal Feeding Operations (CAFOs) generate a large amount of animal waste, which can pollute nearby water sources if not managed properly. The waste can contain pathogens, nutrients, and organic matter that can harm aquatic ecosystems.

10. Natural Sources: Water bodies can also be affected by natural processes, such as volcanic eruptions, erosion, and algal blooms. While these events may not be caused by human activities, they can still lead to water pollution and affect local ecosystems.

Addressing water pollution requires a combination of regulations, improved industrial practices, better waste management, and public consciousness about the importance of protective our water sources. Collaboration between governments, industries, communities, and environmental organizations is crucial to prevent further degradation and promote sustainable water management practices.

Impacts of waste water on living things:

Wastewater, especially when untreated or poorly treated, can have significant negative impacts on living things, including humans, animals, and aquatic ecosystems. Here are some of the key impacts of wastewater pollution:

1. Human Health: Contaminated water can carry harmful pathogens, bacteria, viruses, and parasites that cause waterborne diseases. Common illnesses resulting from wastewater pollution include diarrhoea, cholera, dysentery, hepatitis, and typhoid fever. Children, the elderly, and those with compromised immune systems are particularly vulnerable.

2. Aquatic Life: Wastewater discharges introduce excess nutrients, such as nitrogen and phosphorus, into water bodies. This leads to eutrophication, a process in which rapid algal growth occurs. while those algae die and decompose, they use up oxygen inside the water, growing "lifeless zones" that are inhospitable for plenty aquatic organisms Fish, shellfish, and other aquatic life can suffocate or die due to the lack of oxygen.

3. Biodiversity Loss: Wastewater pollution can disrupt entire aquatic ecosystems. It can lead to the decline or extinction of various species, both in water and on land, as some organisms may rely on specific aquatic habitats for their survival or reproduction.

4. Bioaccumulation and Biomagnification: Some pollutants in wastewater, together with heavy metals and chronic natural pollution, can accumulate in the tissues of aquatic organisms. Through the process of biomagnification, the concentrations of these pollutants increase as they move up the food chain. This means that top predators, including humans, may end up consuming highly contaminated organisms, leading to health risks and toxic effects.

5. Loss of Recreational and Economic Value: Contaminated water bodies can no longer be used for recreational activities like swimming, boating, or fishing. This can lead to a decline in tourism and negatively impact local economies that rely on water-related activities.

6. Aesthetic Degradation: Wastewater pollution can cause foul odours and discoloration of water bodies, reducing their aesthetic appeal. This can lead to reduced property values and decreased enjoyment of natural areas.

7. Disruption of Ecosystem Services: Aquatic ecosystems provide vital offerings, which includes water purification, flood manage, and habitat for wildlife. Wastewater pollution can disrupt these offerings, main to multiplied vulnerability to herbal failures and loss of vital habitats.

8. Contamination of Drinking Water: In some cases, wastewater pollution can contaminate drinking water sources. This poses a direct risk to human health and can lead to widespread illness outbreaks.

Impacts of waste water on non-living things:

Wastewater can have several negative impacts on non-living things, such as water bodies and the environment. It can lead to water pollution, disrupting aquatic ecosystems, and causing harm to plants and wildlife. Excess nutrients and chemicals in wastewater can deplete oxygen levels in water, leading to hypoxia and the death of aquatic organisms. Additionally, pollutants in wastewater can accumulate in soil and sediments, affecting the overall health of the ecosystem. Proper treatment and management of wastewater are essential to minimize this harmful effect.

Addressing wastewater pollution requires proper treatment of sewage and industrial effluents before they are discharged into water bodies. Implementing and enforcing strict regulations on wastewater management is crucial to protect both human health and the environment. Additionally, promoting water conservation, public awareness, and sustainable practices can help reduce the generation of wastewater and its negative impacts on living as well as non-living things.

The Importance of Wastewater Treatment:

Due to the potential hazards of untreated wastewater, proper treatment is essential before its discharge into natural water bodies or reuse. Wastewater treatment serves several crucial purposes:

Environmental Protection: Effective treatment removes pollutants and contaminants from the wastewater, reducing the negative impact on aquatic ecosystems and preserving biodiversity.

Public Health: Untreated wastewater can contain harmful pathogens, leading to waterborne diseases. Proper treatment ensures the protection of public health by eliminating these pathogens.

Resource Conservation: Treated wastewater can be reclaimed and reused for various non-potable purposes, inclusive of irrigation, commercial processes, or groundwater recharge. This reduces the pressure on freshwater resources.

Wastewater Treatment Processes:

Wastewater treatment involves a series of physical, biological, and chemical processes to purify the water.

Common treatment steps include:

Preliminary Treatment: The first stage involves screening to remove large debris, followed by grit removal to eliminate sand, gravel, and other coarse particles.

Primary Treatment: In this step, the wastewater is allowed to settle, during which solid particles (sludge) settle to the bottom, forming primary sludge.

SecondaryTreatment: This stage utilizes biological strategies tointerrupt down natural depen d present within the wastewater. not unusual secondary remedy strategies consist of activated sludge procedure, trickling filters, and built wetlands.

Tertiary Treatment: If better water quality requirements are required, tertiary remedy can be employed. It involves additional filtration and disinfection processes to remove nutrients, pathogens, and other remaining contaminants.

Wastewater management is a critical aspect of environmental stewardship and public health. Proper treatment and responsible disposal or reuse of wastewater are vital to protect natural water resources, ecosystems, and the well-being of communities. Developing sustainable and efficient wastewater treatment practices is essential to address the ever-growing challenge of water pollution in a rapidly developing world.

Waste waters generated from different regions and technique used for purification with their limitations:

Currently disinfectant of drinking water is caried out by using physical and chemical techniques like UV treatment, chlorination, ozonation due to their mass scale application each conventional process has some limitations **[8-11].** Wastewater purification techniques vary depending on the region, available resources, and the specific pollutants present in the wastewater. Here are some common purification techniques used in different regions, along with their limitations:

Table 1: Techniques used for purification with their limitations

Sr.No.	Techniques used	Process	Limitations
1	Activated Sludge Process	The waste activated solids process is a generally used biological treatment method. It involves mixing wastewater with a culture of microorganisms (waste activated solids) in an aerated tank. The microorganisms consume organic matter, converting it into biomass, carbon dioxide, and water.	This process is effective in removing organic pollutants but may not be as efficient in eliminating certain nutrients, pathogens, or persistent pollutants. It also requires significant energy input for aeration.

2	Trickling Filters	Trickling filters are another form of biological treatment. Wastewater is sprayed over a bed of rocks or plastic media, providing a surface for biofilm formation. Microorganisms in the biofilm degrade organic matter as the wastewater trickles through the bed.	Trickling filters are less effective in removing nitrogen and phosphorus compounds, which are common nutrients contributing to eutrophication. They also require regular maintenance to prevent clogging
3	Constructed Wetlands	Set up salt marsh mimic the natural purification activity that occur in wetland ecosystems. Wastewater is directed through shallow, planted basins where different physical, chemical, and biological processes remove pollutants	Constructed wetlands may have limited applicability for certain regions due to land availability and climatic conditions. They might not effectively remove certain persistent organic pollutants.
4	Chemical Coagulation and Flocculation	Chemical coagulants are added to wastewater to destabilize particles, and then flocculants are added to form larger, settleable flocs. This process aids in the removal of suspended solids and some dissolved substances	The use of chemicals can generate additional sludge and may introduce new chemical compounds to the environment. It may not be effective in removing certain dissolved pollutants like dissolved organic compounds and nutrients
5	Membrane Filtration	Membrane filtration involves passing wastewater through fine pores or membranes that selectively remove contaminants based on size or charge	Membrane filtration can be expensive to operate and maintain, especially for large-scale applications. The membranes can foul or become damaged over time, affecting their efficiency.
6	Disinfection (Chlorination, UV treatment, etc)	Disinfection aims to kill or inactivate pathogenic microorganisms present in the wastewater.	Some disinfection methods can produce harmful byproducts or may not effectively remove certain protozoa and viruses. Additionally, overuse of chlorine can lead to the formation of chlorinated organic compounds
7	Reverse Osmosis (RO)	Reverse osmosis is a stress-driven process where water is forced through a semi-permeable laminate, leaving behind most contaminants.	RO is energy-intensive and produces concentrated brine as a byproduct, requiring appropriate disposal. It is not suitable for treating large volumes of wastewater. In conclusion, the choice of wastewater purification technique depends on factors such as the characteristics of the wastewater, available resources, and environmental considerations.

Role of nanomaterials in water purification:

Nanomaterials play an important function in water purification because of unique properties at the nanoscale. They can enhance water treatment processes in various ways:
Increased Surface Area: Nanomaterials have
an excessive surface location to extent ratio, taking into consideration more green adsorption and filtration of contaminants.

Adsorption: Nanostructured materials can selectively adsorb pollutants, such as heavy metals, organic compounds, and microorganisms, from water, effectively removing them.
Catalysis: Certain nanomaterials act as catalysts, accelerating chemical reactions that can break down harmful substances in water, like organic pollutants or disinfecting pathogens.
Membrane Technology: Nanotechnology has enabled the development of advanced nanofiltration and reverse osmosis membranes, which can efficiently remove even smaller contaminants from water.
Photocatalysis: Nanomaterials like titanium dioxide or zinc oxide can be used in photocatalytic processes to degrade organic pollutants when exposed to UV light.
Antibacterial Properties: Some nanomaterials possess natural antibacterial properties, helping to inhibit microbial growth and prevent waterborne diseases.
Nano-adsorbents: These can remove heavy metals, dyes, and other pollutants, making them promising alternatives for traditional water treatment methods.
Nanocomposite Materials: By incorporating nanomaterials into existing water treatment systems, their performance and efficiency can be significantly improved.

However, it's essential to consider potential risks associated with nanomaterials, such as their environmental impact and long-term effects on human health, during their application for water purification. Research and responsible use are necessary to ensure their safe implementation.

List of some common nanomaterials with their limitations:

Table 2: Common nanomaterials used with their roles and limitations

Sr.No.	Common Nanomaterials	Role of nanomaterials	Limitations
1.	Nano silver	Efficient antimicrobial properties	potential toxicity and environmental impact.
2.	Nanoscale Ferrous material Materials (e.g., Zero-Valent Iron, Iron Oxide Nanoparticles)	Effective for removing heavy metals and organic pollutants	might agglomerate, reducing their overall efficiency.
3.	Carbon Nanotubes (CNTs)	Excellent adsorbents for organic contaminants	expensive and challenging to recover after use
4.	Graphene-based Nanomaterials	High surface area for adsorption	cost and scalability can be limiting factors
5.	Nanocellulose	Sustainable and biodegradable material with good adsorption capacity	removing only certain types of pollutants

6.	Nanoscale Metal Oxides	Effective in removing heavy metals and some organic contaminants	efficiency can decrease in the presence of natural organic matter
7.	Nano porous Materials	High adsorption capacity for a wide range of contaminants	stability and regeneration can be challenging
8.	Silver-Modified Zeolites	Exhibit strong antimicrobial activity and effective for some heavy metal	potential leaching of silver raises concerns
9.	Nano-Composite Materials	Synergistic effects of multiple nanomaterials, offering enhanced efficiency	synthesis complexity and high cost.

In recent years most of metal oxides are used in nanotechnology branch for water purification. Here are some metal oxides are listed with their role.

Table 3: List of metal oxide with their Role

Sr.No.	**Metal Oxides**	**Role**
1.	Titanium Dioxide (TiO_2)	Photocatalytic activity can degrade organic pollutants and kill bacteria
2.	Zinc Oxide (ZnO)	Photocatalytic and antibacterial properties
3.	Iron Oxide (Fe_2O_3)	Adsorption capacity to remove arsenic, fluoride, and other heavy metals from water
4.	Manganese Oxide (MnO_2)	Effective in removing heavy metals and arsenic contaminants
5.	Cerium Oxide (CeO_2)	Exhibits photocatalytic and adsorption properties for water purification
6.	Aluminum Oxide (Al_2O_3)	good adsorption capacity for fluoride, arsenic, and organic pollutants
7.	Copper Oxide (CuO)	Shows potential for the removal of organic contaminants from water
8.	Silver Oxide (Ag_2O)	Known for its antimicrobial properties and used for disinfection purposes.

The efficiency of these metal oxides thin films can vary depending on various factors such as the specific application, water quality, film preparation method, and operational conditions. It's always essential to consider the specific requirements and conduct proper testing before implementing them in water purification processes.

Following are the various sources discusses in detail from which waste water is generated from different region with purification process:

1. Domestic Waste water:

Domestic waste water is generated from different household activities such as Bathing, washing clothes and utensils, cleaning-hands, vehicles, home, and toilet waste, etc. Following figure shows the percentile range of generated waste water during domestic work.

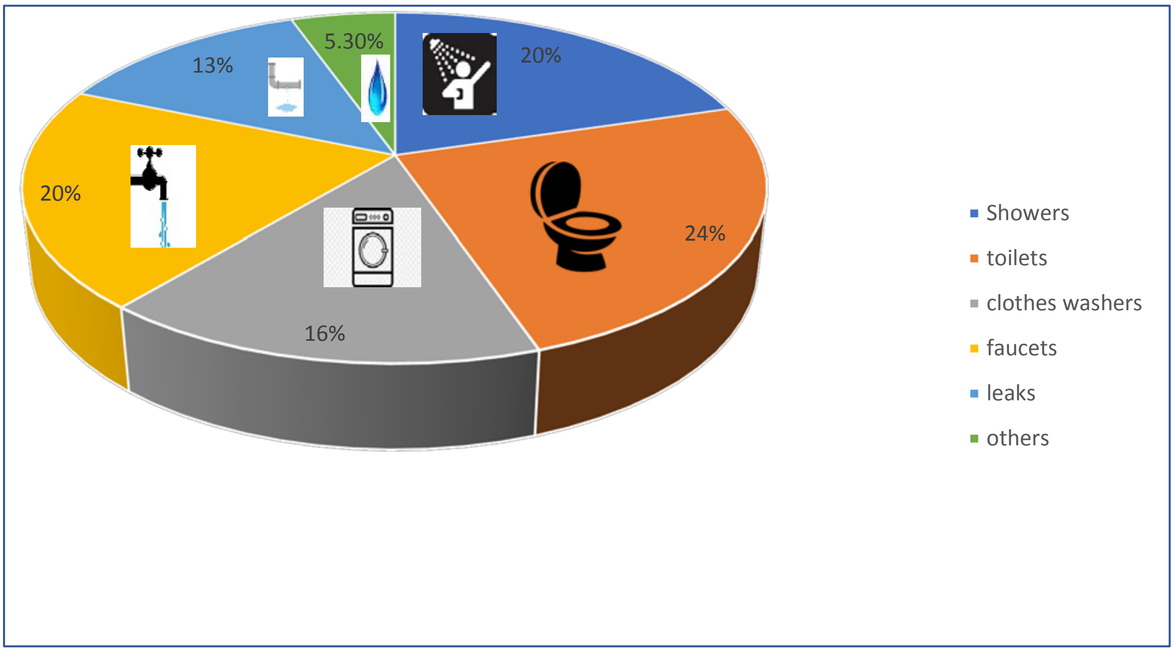

Fig. 1 waste water generated from domestic region.

Thus, depending upon content present in water the waste water generated from different activities classified in to four types.

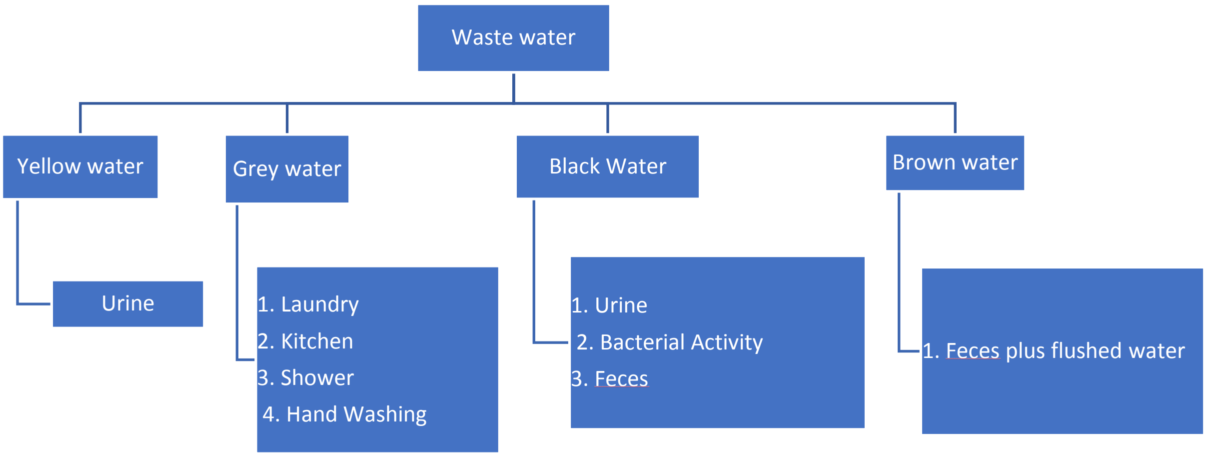

Fig. 2. Waste water generated from different activities.

1] Yellow water – (containing urine) 2] Grey water- (containing water from laundry, kitchen, shower, hand washing) 3] black water - (containing urine, bacterial activity, feces) 4] Brown water – (containing feces plus flushed water) etc. generally waste water from different sources contains heavy metals such as lead (Pb), mercury (Hg), copper (Cu), Chromium (Cr), Nickel (Ni) which are non-degradable and gives rise to biomagnification**. [12]** In recent year due to quick development of economy and due to increasing deteriorations of water environments have already impact on people health and economy's sustainable developments. Therefore, some reasonable and effective techniques have been studied and applied for household sewage treatment**. [13,14,15].**

To remove the impurities from domestic waste water in recent years various techniques are used for this some of them had listed here such as,

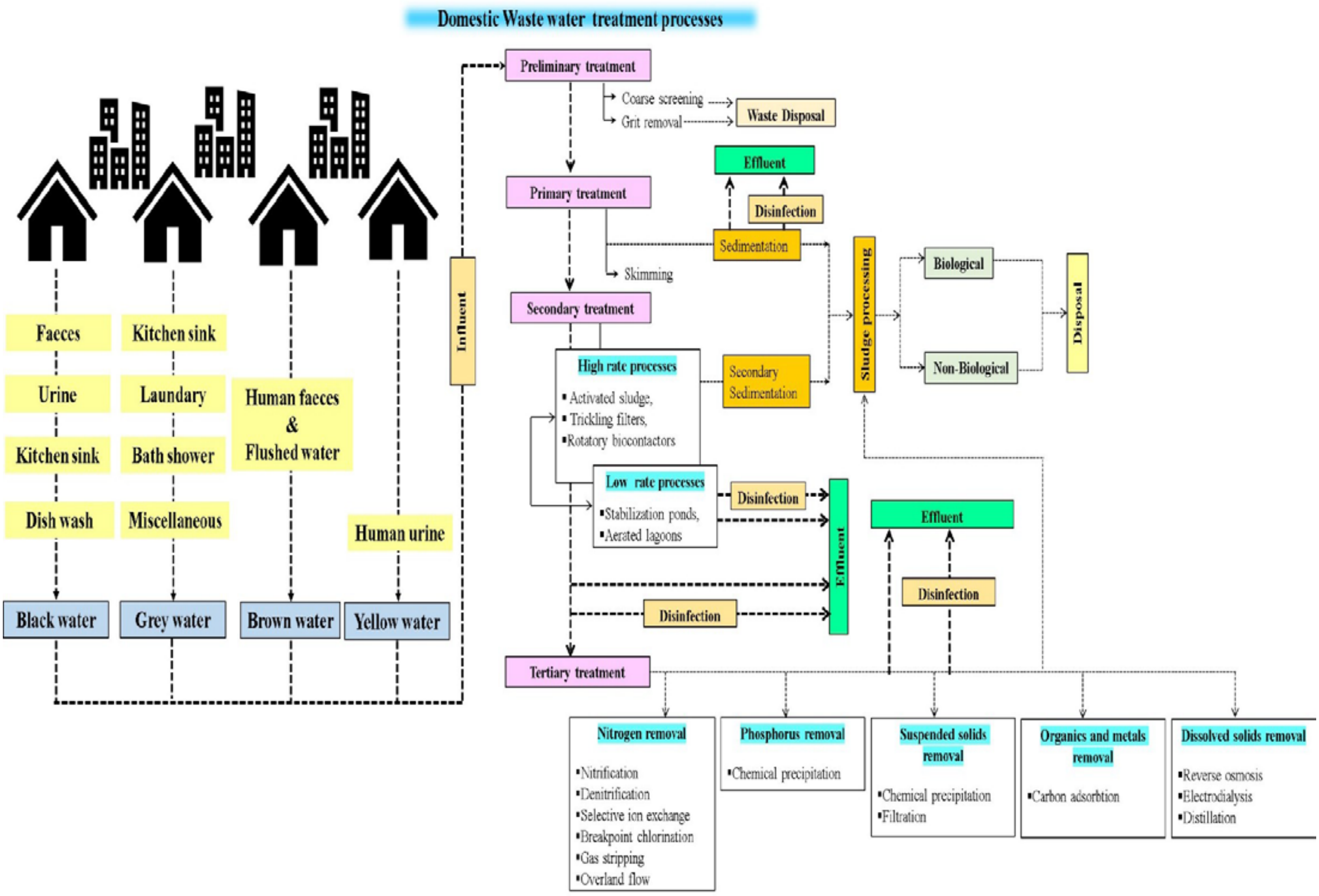

Figure 3. Schematic representation of a general domestic wastewater treatment (WWT) regime

(Figure taken from a review article on **Insights into the Domestic Wastewater Treatment (DWWT)** https://doi.org/10.3390/w14213542 **[25])**

Preliminary Treatment (screening): This plant almost removes all nonorganic solid waste and also remove 25% of organic load. Removed material is disposed in landfill. This treatment is performed to protect plant from physical damage or clogging problems. It also includes sedimentation and coagulation process **[16].** For further removal of suspended particles pre-treatment water is subjected to coagulation and flocculation process **[17].** This treatment is not sufficient to remove colloids and smaller insoluble molecules.

Primary Treatment (primary settling): After the completion of preliminary treatment primary treatment is done. Removed fabric is disposed in landfill. This plant include coagulation, flocculation, precipitation process.

Coagulation: This system entails numerous aluminium or ferric compounds like aluminium sulphate, ferric chloride, sodium aluminate as a coagulant. these materials hydrolysed water and neutralized
suspended rate debris also produce metallic ions included with tremendous expenses.
For next explanation microfiltration procedure is used. organic count number withdrawn in large quantity, but this process does not kill pathogens absolutely. Thus, produced water from this process is not used for drinking **[18].** Dissolve impurities and ions cannot be removed by using this process.

Flocculation: Through the waste water tank particles which are moving with different velocities brings together by flocculation process. The layout flocculation method is normally relying on floc traits which are favoured for filtration technique. **[19]** Small particles can easily pass through the membrane so does no longer sufficient to take away all type of pathogens.

Precipitation: This technique is generally used to remove phosphorus compound, steel ions, radioactive factors which are dissolved in waste water. Generally, calcium and sodium hydroxide compounds are used as a precipitant **[20].** Elements used for precipitation produce toxic fumes and colloidal precipitates also sludge produce gives the problem of a sludge management which is measure disadvantage of this technique **[21-23].**

After completion of primary treatment next treatments are carried out which are listed below.

Secondary Treatment (e.g., activated sludge): During this process biodegradable material and colloidal particles remaining in waste water are get separated. This plant includes adsorption, biodegradation and filtration process. Disadvantages of this plant is that regeneration of activated carbon is costly. Selectivity is also low and regular attention is required.

Tertiary Treatment: After the primary and secondary treatment to remove suspended particles from the waste water tertiary treatment is used. After the secondary treatment this is an additional treatment to remove the nutrients such as phosphorus, and nitrogen. Main disadvantage of this method is that high power consumes and also require high energy. Also process including this treatment are unable to remove virus. Maintenance of this plant is costly.

Electrochemical treatment: This type of technique cannot be used broadly because they require plenty of strength consumption **[24]**. For separations of metal ions from waste water electrochemical treatment is used. All conventional techniques equally are not sufficient against the small microorganism. Disadvantage of this treatment is electrodes are not durable and also sludge produced by this process increases operating cost.

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Final Treatment (disinfection),

Disinfection: After the tertiary treatment this is a final treatment to kill remaining pathogenic bacteria, viruses by using UV rays, chlorine compound, chemical oxidant, etc. but disadvantage of this method is that change in odour and taste also it has long term effects of biproducts. Including all this process makes the waste water reusable **[25].**

Role of Metal oxides used for domestic waste water purification shown in following table,

Table 4: List of metal oxide used domestic water purification

Sr. No.	Name of metal Oxides	Role of metal oxides in purification of water
1	Activated Alumina	Removes fluoride, arsenic, and other heavy metals from water
2	Iron Oxide (Fe_3O_4)	Effectively removes arsenic and other heavy metals
3	Manganese Dioxide (MnO_2)	Removes iron, manganese, and hydrogen sulphide from water
4	Titanium Dioxide (TiO_2)	Used in advanced oxidation processes to degrade organic pollutants
5	Zeolite	Removes ammonia, heavy metals, and some organic compounds
6	Magnesium Oxide (MgO)	Used in alkaline water filters to raise pH and reduce acidity

2. Industrial Waste water:

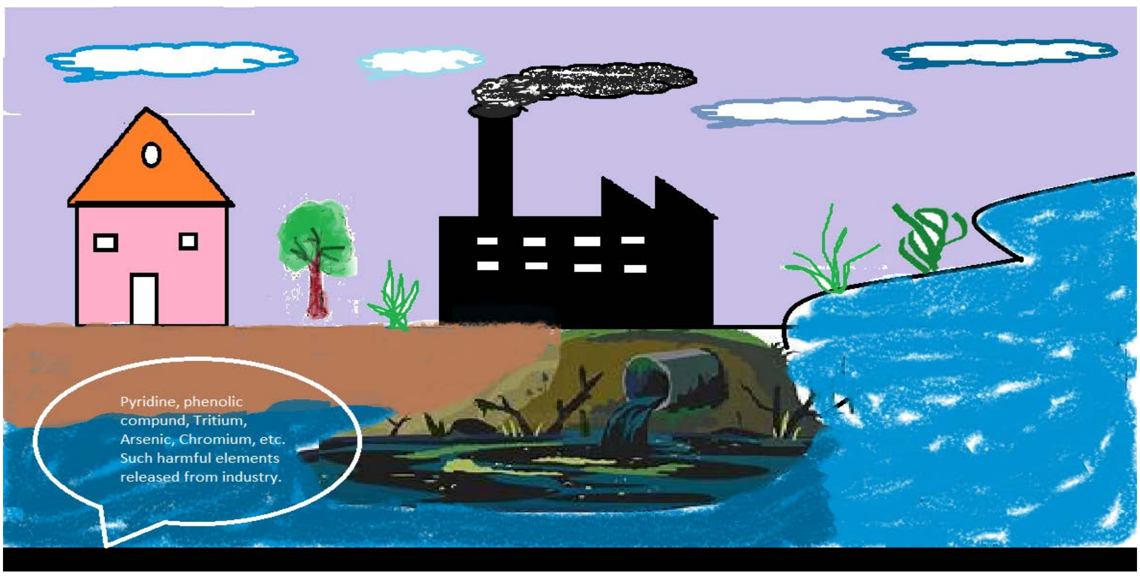

Fig. 4 Industrial Water Pollution

Industrial waste water contains very harmful chemical element such as pyridine (There is a lot industries like dyes, herbicides, shale oil processing released pyridine. This is one of measure pollutant found in water which released from industries.), phenols, phenoxides chlorophenols (phenolic compound are found from waste material like formaldehyde resins,

lacquers and binders, pharmaceuticals and pesticides, from cooking and coal distillation plant and in soil greens residue.), Tritium (Tritium is radioactive isotope of water it is able to be devour or absorbed into the fame without difficulty. At higher concentration it causes more serious problem, especially when it is interrupt in to water. Content of tritium is found in stream of waste water generated from nuclear plant.), Arsenic (Concentration of an arsenic in natural water is a worldwide problem. Many countries from world are affected due to groundwater contamination of arsenic. This element is very toxic and dangerous.), Chromium (This element is found in baths of tannery, galvanoplasty, metallurgical industry, textile. It additionally outcomes on human fitness which growth the hazard of lung, nasal and sinus most cancers. Usually, painless pores and skin ulcers can result whilst contact with Chromium (Cr).

Depending upon the needs of the civilization various methods used to remove contaminants from waste water. To remove pyridine and phenolic derivatives from waste water, advanced oxidation and natural adsorbents are used **[26]**. Also, each element is removed through the use of adsorption at high location the usage of c-cloth electrode **[27].** Advanced oxidation process: For degradation of pyridine AOP'S is carried out in four process such as photon and photo Fenton process, photocatalytic process and UV/H_2O_2 process. In photo-Fenton's process maximum removal COD is obtained for PH 2.0. The value of PH effects on COD removal. For removal of COD rate of degradation is higher for lower PH. When pH decreases from 4.0 to 2.0 only 6% increase in removal of COD. When reaction is carried out of waste solution with TiO_2 and H_2O_2, there is no effect is observed of PH on COD removal **[28].** Also, C-Cloth electrodes are used as quasi three D- interfaces that's coupled with UV-Vis Spectrophotometric method. In this process pyridine is completely removed by anodic polarization **[29]**. In this process electrolyte has very vital role for elimination of pyridine. For chromium and chromate ions solvent extraction and adsorption using natural adsorbents methods are generally used**. [30]** solvent extraction and adsorption using herbal adsorbents method for elimination of chromium ions: For extraction of chromium ions extraction of exchange 'd' anions mechanism is mostly used. By using this method, it is concluded that subsequent desorption from ac at lower PH price assist to remove chromate ion in larger proportion from the solution. From this method organic material removed from solid surface gives excessive surface region which acts as boon for disposing of chromate ions **[31]**. Whereas catalytic electrolysis and membrane separation methods are used to remove tritium **[32].** catalytic electrolysis and membrane separation method for removal of tritium: in this method various stages are designed to separate tritium from water. About 95% tritium is removed by using membrane separation method. This process is done under glove box to prevent contamination of tritium with environment.

By using precipitation method, a heavy metal arsenic can be removed **[33]** Precipitation method for removing of Arsenic and heavy metals: In this process firstly arsenite is oxidize to arsenate by through the use of potassium permagnette. 2^{nd}step is that precipitation with ferric sulphate and slaked lime under PH adjustment. By using this method removal efficiency of heavy metals from the waste water is about 99.99%.

Role of Commonly used Metal oxides for Industrial waste water purification shown in following table,

Table 5: List of metal oxide used Industrial waste water purification

Sr. No.	Name of metal oxide	Role of metal Oxide in water purification
1	Activated Alumina	Effective in removing fluoride, arsenic, and other trace contaminants
2	Iron Oxide (Fe_3O_4)	Used in processes like coagulation and flocculation to remove suspended solids and heavy metals
3	Manganese Dioxide (MnO_2)	Removes iron, manganese, and hydrogen sulphide from water, often in combination with other media
4	Titanium Dioxide (TiO_2)	Utilized in advanced oxidation processes for the degradation of organic pollutants
5	Zirconium Oxide (ZrO_2)	Removes heavy metals and radioactive substances from water
6	Magnesium Oxide (MgO)	Used in pH adjustment and to remove heavy metals

3. Agricultural Waste water:

Water pollution from agriculture create poor impact on human fitness. Aquatic ecosystem also effected due to agricultural water pollution. Due to increasing population and their continuous demand various toxic chemical fertilizers are used in agriculture. So, to increase the quantity of food, in recent years as compare to 1960s the world consumes 10 times more mineral fertilizer **[34]**. Fertilizer use has no

longer grown evenly international. major inequality exists among the one's components of an international with too many nutrients and people with deficient. Because, nutrients are direct transferred to water bodies. Nitrate is the maximum chemical contaminant from agriculture in the world's groundwater level. Agricultural is the main supply of pollution in rivers and streams, in America. Second supply is wetland, and third important supply in lakes. Agriculture is accountable in massive scale for surface water pollutant and also chargeable for nearly solely for groundwater pollution by means of nitrogen, in China **[35, 36].** In recent year many countries intensively used pesticides, herbicides and fungicides regularly in agriculture. Extensive use of chemical fertilizer can pollute water resources with cancer agents and different toxic substances that offers horrific effect on human health.

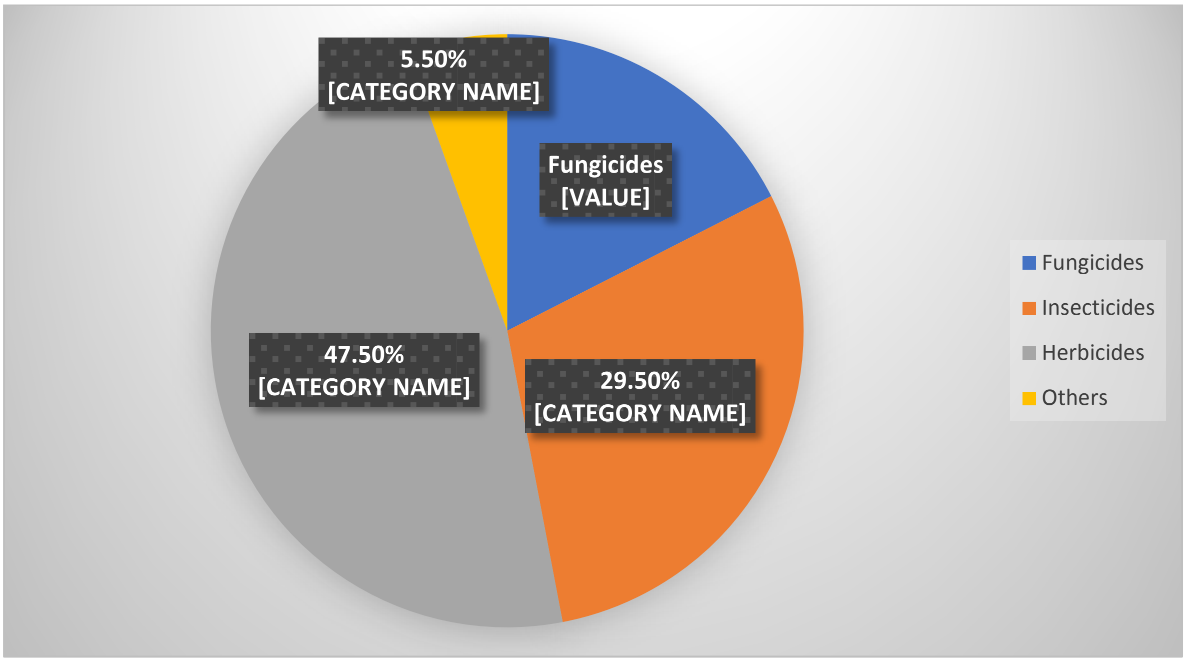

Fig. 5 Use of Fungicides, insecticides, Herbicides in Agriculture

Table 6: Discuss a List of pesticides and their effect on human body

Fungicides	Effects on Body	Insecticides	Effects on Body	Herbicides	Effects on Body
Benomyl	Ciarrhosis	DDT	Carcinogenic	Glyphosate	Nervous system
Metiram	Thyroid Gland	Dieldrin	Dizziness	Metribuzin	Organ Weight
Nabam	Nerve Damage	Endosulfan	Diarrhea	Dacthal	Liver Damage
Zineb	Diarrhea	Dicofol	Headache	Sethoxydim	Tremors
Dichloran	Kidney	Methoxychlor	Nervous system	Trifluralin	Dermal irritation

There are different techniques used for removing pesticides from waste water. Rain water is a major source of contaminant, to remove the contaminants from agricultural waste water Iron-enhanced sand filters (IESFs) technique is used. For large scale it is implies that (IESFs) not a promising technique to remove all pesticides from waste water **[37].** A aggregate of a physical, chemical and biological strategies were utilized to bring out explicate the problem of removable of pesticides from waste water, this type of treatment has been used in current techniques. Each treatment has its own advantages and limitations not depends only in terms of cost but also in terms of environmental impact, pre-treatment requirement, reliability, operability, efficiency. Advanced Oxidation process (AOPs) is also used to remove pesticides from waste water. It requires less retention time, also produce less sludge but it has a high operational and maintenance cost **[38].** Another chemical treatment is a photochemical degradation it does not require a potential to form a bromated bioproduct, but it leads to some drawback that it forms large amount of ferrous ion sludge and also form high concentration of anion in treated waste water. However, it also requires low PH range (2.5-4) which increase operating cost **[39].** Another chemical treatment is chlorination, which is cheap and easy chemical technique but pre-chlorination cause more toxic and less removable biproduct. Biological treatment is also used for waste water purification which does not require large land area and also more environmentally friendly than chlorination however, it needs skilled manpower for operations and maintenance **[40]**. Membrane bioreactors are effective for pesticides removal, but membrane fouling and roughness are another drawback **[41].**

In agricultural wastewater purification, metal oxides can also play a role in efficiently removing certain contaminants. Some of metal oxides are listed below in following table:

Table 7: List of metal oxide used Agricultural waste water purification

Sr. No.	**Name of metal Oxide**	**Role of metal oxide**
1	Iron Oxide (Fe_3O_4)	Helps in the removal of phosphates, heavy metals, and other suspended solids from agricultural runoff
2	Aluminium Oxide (Al_2O_3)	Used for the adsorption of phosphates and certain organic compounds in agricultural wastewater
3	Titanium Dioxide (TiO_2)	Applied in advanced oxidation processes to degrade organic pollutants and pesticides in agricultural effluents
4	Magnesium Oxide (MgO)	Can be used in combination with other treatments for pH adjustment and removal of heavy metals

Agricultural wastewater can be quite complex, containing various contaminants such as nutrients, pesticides, and organic matter. Effective treatment often involves a combination of techniques, including metal oxides, biological processes, filtration, and more, tailored to the specific characteristics of the wastewater to achieve efficient purification and minimize environmental impact.

Pharmaceutical waste water:

Pharmacy enterprise recognized as a maximum promising worldwide enterprise which encompass high efficiency, high technology and high investment **[42]**. Pharmaceutical waste water contained many varieties of organic pollution at high concentration NH_3-N, COD, BOD_5 in a complex form of a composition and also contain high levels of toxicity, color depth, suspended solids and other capabilities **[43].** Also due to multistep reaction, hazardous bi-products are also formed such as steroids, nitro compound, fluorine, aniline, chromium, copper, benzene, chloroform, ethanol, petroleum, ether, waste acids and other pollutants which causes more serious problems when they are mixed in to water **[44].** Wastage generated during the production of a pharmaceuticals is more than actual final product. It has reported that typically for every kilogram 200 to 30,000 waste generated of active ingredient produced **[45].** Various types of diseases e.g., Hodgkin's disease, lung cancer, prostate cancer, etc. caused due to this harmful waste chemicals which produced by pharmaceutical industry.

So, to avoid such impacts various treatments are used to purify waste water produced by pharmaceutical industry. Such as

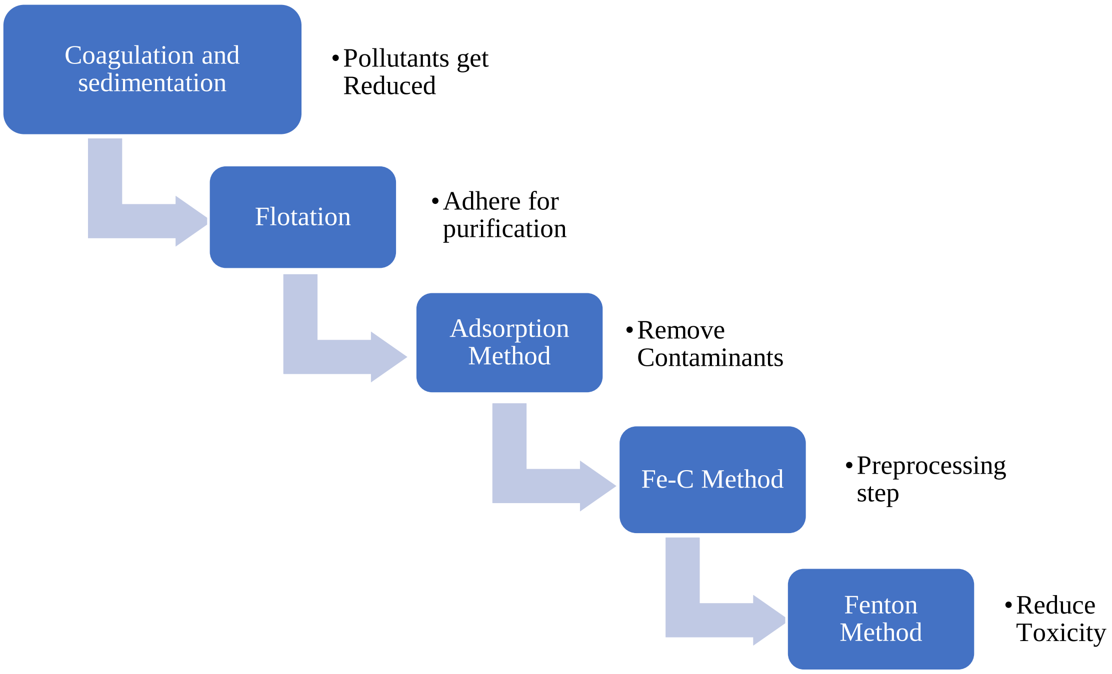

Fig. 6 Techniques used for purification in pharmaceutical waste water

1. Coagulation and sedimentation: By the way of usage concentration of pollutants get reduced and also additionally biodegradability of waste water can be improved.
2.Flotation: This Process is done using quite whispered tiny bubbles as a carrier to stick for purification. Separation of the pollutants is done under solid-liquid or liquid-liquid phase. Advantages of this method is that easy maintenance, simple process, less investment, low energy consumption.
3. Adsorption Method: From one or several pollutants porous solids from waste water is used in adsorption method, to recover and remove the contaminants from waste water. To remove the waste water color and odor in pharmaceutical waste water treatment generally soot or carbon adsorption waste water pretreatment manufacturing medicine, lincomycin is used.
4. Fe-C approach for Micro-electric field: This is a preprocessing step in pharmaceutical waste water treatment. This method is economic and stable over other methods.
5. Fenton method: By using this method COD removal rate is about 40-50%. And the decolonization rate is about 100%. Effectively Low-cost technique and efficiency is about 60-95%.etc. This method reduces toxicity in waste water **[44].**

In pharmaceutical wastewater purification, some metal oxides are employed for their efficiency in removing pharmaceutical compounds and other pollutants. Some metal oxides commonly used are listed in following table

Table 8: List of metal oxide used in pharmaceutical waste water purification

Sr. No.	Name of metal oxide	Role of metal oxide for waste water purification
1	Titanium Dioxide (TiO_2)	Utilized in advanced oxidation processes (AOPs) to degrade organic compounds and pharmaceutical residues
2	iron oxide (fe_3o_4)	used for the adsorption and removal of organic pollutants and heavy metals from pharmaceutical wastewater
3	aluminum oxide (al_2o_3)	helps in adsorbing certain pharmaceutical compounds and organic pollutants
4	zirconium oxide (zro_2)	effective in removing heavy metals and radioactive substances from pharmaceutical wastewater

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