A PROJECT REPORT

ON

DESIGN OF WATER TREATMENT PLANT AT JAWAHAR NAGAR, VARANASI

Submitted as a part of Design Project for CE527

MASTER OF TECHNOLOGY

in

ENVIRONMENTAL ENGINEERING

Submitted by

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LIST OF ABBREVIATIONS

BIS	:	Bureau of Indian Standards
CPHEEO	:	Central Public Health and Environmental Engineering Organization
CPWD	:	Central Public Works Department
DO	:	Dissolved Oxygen
BOD	:	Biological Oxygen Demand
MPN	:	Most Probable Number

ABSTRACT

This project aims to address the pressing need for a water treatment plant (WTP) in Jawahar Nagar, where prevalent drinking water problems have led to waterborne diseases, posing a significant threat to public health. The primary objective is to design and calculate each unit of the WTP with the ultimate goal of providing the community with clean and safe drinking water.The design of the water processing units will be based on thorough assessments of estimated water demand and specific unit process requirements. The project's focal point revolves around utilizing the Ganga River as the primary water source for the selected location, making it imperative to implement an effective WTP to treat this water adequately. The project will present detailed design steps and calculations for each unit of the water treatment plant. The significance of this endeavor lies in the critical role that the WTP plays in meeting domestic and drinking water requirements. By addressing each unit individually, from intake to clariflocculation, sedimentation, filtration, disinfection, storage, and pumping, the project ensures a systematic and well-rounded solution for delivering safe and potable water to the community.

The objectives of this work encompass two vital aspects. Firstly, it seeks to evaluate the specific water demand of the community in question, enabling the design to be tailored precisely to the needs of the population. Secondly, the project will present a comprehensive set of design steps and calculations for all the units required to construct an efficient WTP.

Chapter 1

Introduction

Water scarcity is a pressing global issue that affects millions of people, ecosystems, and industries. Despite the fact that Earth is covered by approximately 71% water, only a small fraction of it is fresh water, accessible for human consumption. The majority of this freshwater is locked in ice caps and glaciers or lies deep underground, making it unavailable for immediate use. Consequently, the limited availability of clean and safe water has become a significant challenge for various regions worldwide. There are several factors contributing to water scarcity. Population growth, rapid urbanization, industrialization, and agricultural expansion have increased water demands significantly. Additionally, climate change exacerbates the problem by altering precipitation patterns and leading to more frequent and severe droughts. Over-extraction of groundwater for agriculture and other purposes has caused aquifers to deplete faster than they can recharge, further aggravating the situation.

Water treatment plays a crucial role in addressing water scarcity. It involves the process of purifying water from various sources, such as rivers, lakes, reservoirs, and underground aquifers, to make it safe for human consumption and industrial use. Proper water treatment not only ensures access to clean drinking water but also helps preserve ecosystems and protect public health. In response to the water crisis, water treatment plants (WTPs) play a crucial role in purifying raw water from various sources, removing impurities, microorganisms, and contaminants to make it safe for human consumption and other domestic purposes. By employing a series of treatment processes, WTPs ensure the delivery of clean and potable water to communities, contributing to public health and well-being. Access to clean and safe drinking water is an essential requirement for human health and well-being. To meet the increasing demand for high-quality water, the design of an efficient water treatment plant is of utmost importance. This project aims to outline the fundamental considerations and engineering principles involved in developing a water treatment plant that ensures the delivery of safe and potable water to communities.

Significance of Water Treatment: Natural water sources, such as rivers, lakes, and groundwater, often contain impurities and contaminants that can pose health risks. Water treatment is a crucial process that purifies the raw water and makes it safe for consumption, industrial use, and other domestic purposes.

Objectives

The objective of the project are as follows:

i) Meeting Water Quality Standards: The design of the water treatment plant will be based on water quality assessments to ensure compliance with stringent national and international standards for drinking water. It will prioritize the removal of harmful substances and microorganisms to deliver water of the highest quality.

ii) Tailoring to Local Conditions: Each location has unique characteristics and challenges related to water quality and availability. The design will be specifically tailored to address the specific needs and conditions of the area, considering the type of water source, climate, and population size.

iii) Selection of Treatment Processes: The project will explore a wide range of treatment processes, including coagulation, filtration, disinfection and the choice of treatment processes will be guided by the characteristics of the raw water and the desired water quality goals.

The primary objective of the water treatment is to eliminate disease causing impurities and nuisances, ultimately providing safe, visually appealing and pleasant tasting drinking water.

Chapter 2

Description of the study area

2.1 About the study area

Jawahar Nagar is situated in the Bhelupur locality of Varanasi, which is one of the oldest and most historically significant cities in India. Varanasi, also known as Banaras or Kashi, is renowned for its cultural, religious, and spiritual heritage. Jawahar Nagar is primarily a residential neighborhood. It consists of houses, apartments, and residential buildings, accommodating a mix of local residents and families. The area is well-connected to the rest of Varanasi through various roadways. It is close to the Bhelupur Chauraha (crossing) and has easy access to public transportation like buses and auto-rickshaws. Residents in Jawahar Nagar have access to essential amenities and services, including schools, medical facilities, grocery stores, and local markets. Bhelupur and nearby areas offer a range of shops and restaurants catering to everyday needs. Jawahar Nagar is near many famous temples, ghats, and places of spiritual importance. The city is a major pilgrimage site for Hindus and attracts visitors from all over India and the world. Overall, Jawahar Nagar Colony in Bhelupur, Varanasi, provides its residents with a mix of urban conveniences and cultural richness, making it a desirable place to live for those seeking a blend of modernity and traditional charm in one of India's oldest cities.

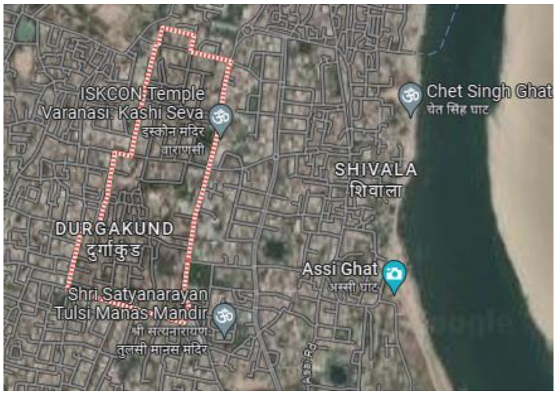

Fig.2.1: Aerial map of Jawahar Nagar showing the location

Table 2.1: Basic data of Jawahar Nagar

Sl No.	Description	
1.	Name of the place	Jawahar Nagar
2.	District	Varanasi
3.	Area	0.39 km^2
4.	Population	13189
5.	Location a) About 18.54 km from Lal Bahadur Shastri Airport b) About 2.26 km from Manduadih Railway Station c) On the right bank of river Ganga	

2.2 Necessity of the project

It is of utmost importance to establish a water treatment plant in the locality of Jawahar Nagar due to the prevailing concerns related to waterborne diseases and water quality. The health and well-being of the community are at risk, making it a significant requirement that should be addressed promptly. Waterborne diseases have recently posed considerable threats to public health in Jawahar Nagar. Outbreaks of diseases like cholera, typhoid, dysentery, and gastroenteritis have been a cause for alarm, highlighting the urgent need for measures to ensure the safety of the water supply. A water treatment plant would play a crucial role in safeguarding the community against these pathogens by purifying the water and making it safe for consumption.

Furthermore, the existing water sources in Jawahar Nagar may be contaminated with harmful pollutants and chemicals, making the water unsuitable for human use. Foul-smelling or discolored water indicates the presence of impurities that require effective removal. A water treatment plant would address these concerns, significantly enhancing water quality and eliminating potential health hazards. As the population continues to grow and urbanization progresses, the demand for clean water will inevitably rise. This escalating demand can put a strain on the existing water resources, potentially leading to compromised water quality. It is essential to have a robust water treatment facility in place that can cater to the increasing needs of the community and ensure a sustainable supply of clean and safe drinking water. In addition to mitigating the risks posed by waterborne diseases, a water treatment plant can act as a preventive measure. By treating the water at the source, the community can proactively protect itself from potential future health crises and water-related illnesses. Compliance with water quality standards is crucial to public health protection. Establishing a water treatment plant in Jawahar Nagar would enable the community to meet or exceed the required standards set by health authorities, ensuring that the water supply is safe for all residents.

In conclusion, the establishment of a water treatment plant in Jawahar Nagar is an absolute necessity to address the prevailing concerns of waterborne diseases and water quality. By providing a dependable source of clean and safe drinking water, the community can significantly improve public health and secure a better quality of life for its residents. Timely action is required to ensure the well-being and prosperity of Jawahar Nagar's inhabitants, making the installation of a water treatment plant an urgent and critical priority.

Chapter 3

Water Source and Quality Analysis

The Central Public Health and Environmental Engineering Organization (CPHEEO) manual provides guidelines for various aspects of water supply and wastewater management in India. According to the CPHEEO manual, the following are the typical water sources considered for a water treatment plant:

Surface water sources: Rivers, lakes, and reservoirs, play a significant role in meeting the water demands of urban and rural areas. They are an important natural resource and are commonly used as water sources for water treatment plants worldwide, including in India as per the CPHEEO manual.

(a) Rivers

Rivers are major surface water sources, often serving as a primary water supply for communities. They are dynamic systems, influenced by factors like rainfall, snowmelt, and human activities in their catchment areas. Rivers carry water from higher elevations to lower areas, making them readily accessible for water intake. However, they are also susceptible to fluctuations in flow rates and water quality due to seasonal changes and human-induced alterations. The water quality of rivers can vary significantly, depending on upstream pollution, industrial discharges, agricultural runoff, and urban waste discharge. Treatment plants need to be equipped to handle varying raw water quality, employing processes such as coagulation, flocculation, sedimentation, and filtration to remove impurities and suspended solids. Disinfection is crucial to ensure the removal of pathogens, making the water safe for consumption.

(b) Lakes

Lakes are large bodies of water formed by natural processes or human-made reservoirs. They can serve as water sources for water treatment plants, providing a relatively stable water supply compared to rivers. Lakes can act as storage reservoirs, regulating water flow during periods of drought or heavy rainfall. The water quality of lakes can be influenced by similar factors as rivers, including surrounding land use and anthropogenic activities. Contaminants such as nutrients, algae, and sediments may be present in lake water. Water treatment processes for lake water may include similar steps as rivers, with additional measures to manage algal blooms or specific lake-related issues.

(c) Reservoirs

Reservoirs are man-made impoundments created by damming rivers to store water for various purposes, including water supply, hydropower generation, and flood control. Reservoirs provide a controlled and reliable water source, making them essential for meeting the water demands of growing populations. As with lakes and rivers, reservoir water quality can be affected by the catchment area and upstream activities. Reservoirs may experience changes in water quality due to sedimentation and stratification. Water treatment processes for reservoir water typically involve a combination of physical, chemical, and biological treatments to ensure safe and clean water supply.

Groundwater:

(a) General

Rain water percolating into the ground and reaching permeable layers zone of saturation constitutes groundwater source. reach of vegetation except certain species of plants called phreatophytes, and is usually free from evaporation losses. Groundwater resources are less severely affected by vagaries of rainfall than surface water resources.The water as it seeps down, comes in contact with organic and inorganic substances during its passage through the ground and acquires chemical characteristics representative of the strata it passes through. Generally, groundwaters are clear and colorless but are harder than the surface waters of the region in which they occur. In limestone formations, groundwaters are very hard, tend to form deposits in pipes and are relatively non-corrosive. In granite formations they are soft, low in dissolved minerals, relatively high in free carbon dioxide and are actively corrosive. Bacterially, groundwaters are much better than surface waters except where subsurface pollution exists. Groundwaters are generally of uniform quality although changes may occur in the quality because of water logging, over-draft from areas adjoining saline water sources and recycling of water applied for irrigation and pollution. While some of the chemical substances like fluorides and those causing brackishness are readily soluble in water, others such as those causing alkalinity an hardness, are soluble in water containing carbon dioxide absorbed from the air or from decomposing organic matter in the soil. Such decomposing matter also removes the dissolved oxygen from the water percolating through. Water deficient in oxygen and high in carbon dioxide dissolves iron and manganese compounds in the soil. Hydrogen Sulphide also occurs sometimes in groundwater and is associated with the absence of oxygen, the decomposition of organic matter or the reduction of sulphates. Percolation into the sub-soil also results in the filtering out of bacteria and other living organisms. in fissured and creviced rock formations such as limestone, however, surface pollution can be carried long distances without material change.

(b) Spring

Springs are due to the emergence of groundwater to the surface. Till it issues out on the surface as a spring, the groundwater carries minerals acquired from the subsoil layers, which may supply the nutrients to microorganisms collected spring if it flows as a surface stream. Spring waters from shallow strata are more likely to be affected by surface pollutions than deep-seated waters. Springs may be either perennial or intermittent. The discharge of a spring depends on the nature and size of catchment, recharge and leakage through the sub-surface. Their usefulness as sources of water supply depends on the discharge and its variability during the year.

The CPHEEO manual emphasizes the importance of selecting the appropriate water source based on the specific hydrogeological conditions, water quality, and local requirements. Each water source has its unique characteristics, and the treatment processes may vary depending on the source's raw water quality. Regardless of the water source chosen, proper treatment and disinfection processes are essential to ensure the water supplied to the community is safe and meets the required quality standards for drinking and domestic use.

3.1 Identification and Evaluation of Water Sources

3.1.1 Source of water: Ganga River as the primary water source for the water treatment plant. The catchment area of the Ganges River, also known as the Ganga, covers an area of 8,61,404 km^2 and falls in four countries, namely India, Nepal, Tibet, and Bangladesh, with the major part in India. The average annual discharge is 4,93,400 million cubic metreand supplies one of the largest populated areas in the world. The main tributaries are Yamuna, Ramganga, Gomti, Ghaghara, Gandak, Damodar, Kosi& Kali-East and Main sub tributaries Chambal, Sindh, Betwa, Ken, Tons (beyond FiveStates), Sone & Kasia-Haldi. The major cities located on the bank are Srinagar, Rishikesh, Haridwar, Roorkee (in Uttarakhand), Bijnor, Narora, Kanauj, Kanpur,Allahabad, Varanasi, Mirzapur (In UttarPradesh), Patna, Bhagalpur (In Bihar) andBahrampur, Serampore, Hawarah and Kolkata (inWest Bengal)The Ganga basin accounts for a little more thanone-fourth (26.3%) of the country’stotalgeographical area and isthe biggest river basinin India, covering the entire states of Uttarakhand,Uttar Pradesh (UP), Bihar, Delhi, and parts ofPunjab, Haryana, Himachal Pradesh, Rajasthan,Madhya Pradesh, and West Bengal. The Ganga basin is bound in the north by the Himalayas and in the south by the Vindhyas. The main river stream originates in the Garhwal Himalaya (300 55’ N,7907’ E) under the name of the Bhagirathi (Singh and Katiyar, 2020).

3.2 Raw Water Quality and Contaminant Identification for River Ganga at Varanasi u/s (Assighat), Uttar Pradesh

Sl no	Parameters	Actual	BIS	Means for treatment
1.	pH	6.92-7.9	6.5-8.5	Not necessary
2.	Temperature (C)	21.10-23.89	-	-
2.	Electrical conductivity (mS/cm)	0.33-0.47	-	-
3.	Turbidity (NTU)	55-70	1	Clariflocculator and Rapid sand filter
5.	Dissolved Oxygen (mg/l)	6	-	aeration
6.	BOD (mg/l)	1.5-4.3	<2	-
7.	MPN/100ml	1600	0	disinfection
8.	Iron (mg/l)	0.561	0.3	aeration
9.	Manganese (mg/l)	0.112	0.1	-
10.	Chloride (mg/l)	50-73	250	-
11.	Total Dissolved Solids (mg/l)	528	500	-

Source: "National Water Quality Monitoring Programme (NWMP)" data for 2021

Chapter 4

Water-treatment processes

Past practices in America have often been to obtain the purest possible source, even at the expense of transporting water over long distances, and to deliver it to the consumer with little or no treatment. Some cities still own large tracts of land near the headwaters of stream and restrict activities on these watersheds to minimize contamination. Although the benefits of source protection are recognized as a "first line of defense" in preserving water quality, all natural waters will require some degree of treatment in order to meet modern drinking-water standards. The nature and extent of treatment will, of course, depend upon the nature and extent of impurities.

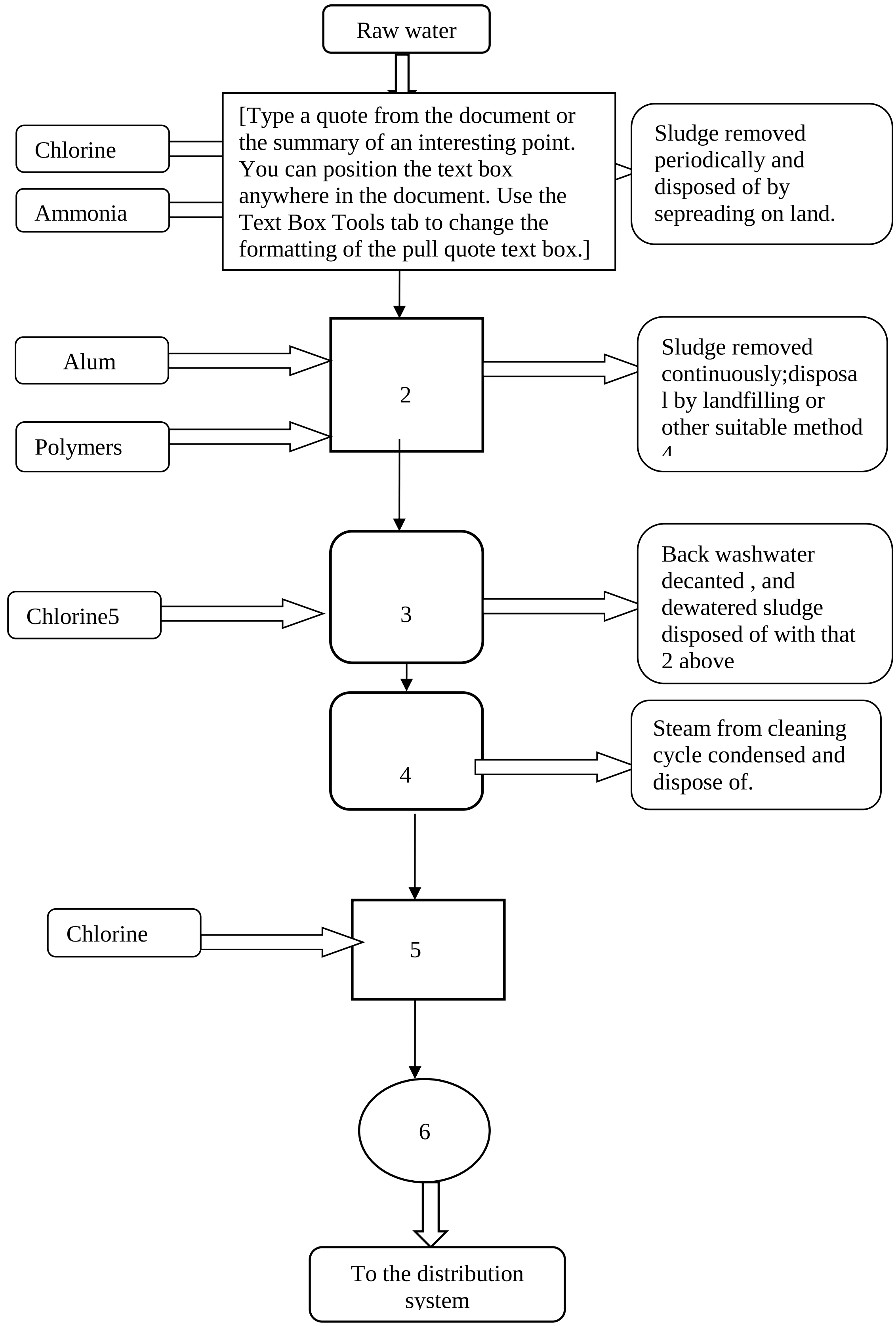

Fig 4.2: Flow sheet treating turbid surface water

Treatment flow sheet

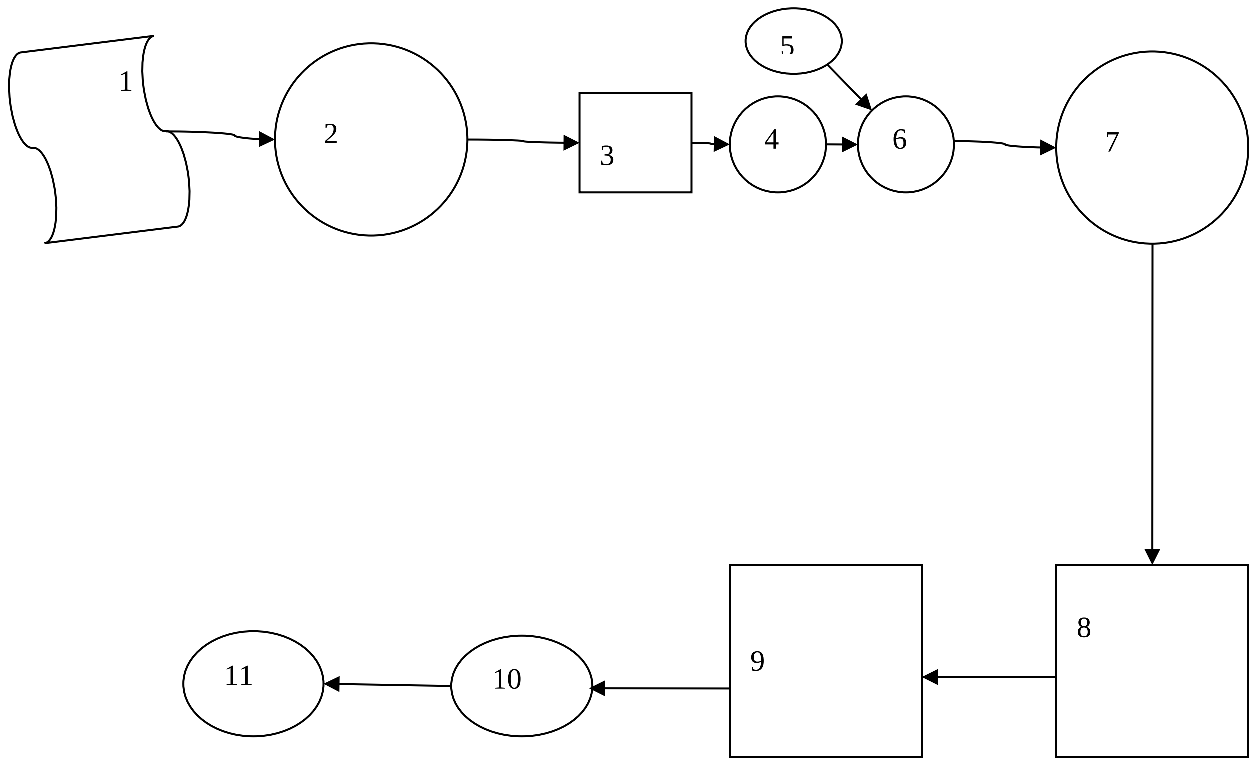

Fig 4.1: Flowchart of Water Treatment Plant (WTP)

1. Surface source (Ganga river)
2. Intake structure
3. Pre-sedimentation Tank
4. Aeration unit
5. Coagulant addition (Ferric-alum coagulant)
6. Flash Mixer
7. Clariflocculator
8. Rapid Sand Filtration
9. Clear Water Reservoir
10. Disinfection unit
11. Distribution system

Justification of each unit:

1. Intake structure: Intake structure is a crucial component for the water treatment plant. The intake structure is responsible for the collection and extraction of water from the river and directing it into the treatment process. The intake structure is needed to ensure that the water collected is representative of the overall river water quality.

2. Pre-sedimentation Tank: A pre-sedimentation is needed to allow the heavier particles, such as sand, silt, and debris, to settle at the bottom of the tank under the influence of gravity. The settled particles form a layer of sludge, while the clearer water above undergoes further treatment processes. This unit is needed in order to reduce the load on subsequent treatment units and improve the overall efficiency of the water treatment process.

3. Aeration unit: In the raw water there were presence of iron manganese which justifies the reason for aeration unit. Aeration is a proven and effective method for removing iron and manganese from water. These metals are commonly found in natural water sources and can cause staining, discoloration, and taste issues. Aeration facilitates the oxidation of ferrous iron and manganous manganese, converting them into their insoluble forms, which can then be easily removed through subsequent filtration processes. This will result in improved water quality and meet the required standards for safe drinking water.

4. Flash mixing: The reason for using a flash mixer in this water treatment plant is to facilitate the rapid and efficient mixing of chemicals such as coagulants, with the raw water and the main purpose is to ensure proper chemical dosing and dispersion for effective water treatment.

5. Clariflocculator: Since the raw water is very turbid the need for clariflocculator arises as it will destabilize the fine suspended particles and colloidal matter. These coagulants neutralize the charges on the particles, causing them to clump together to form larger particles called flocs. The coagulation process is followed by flocculation, during which gentle mixing ensures the growth and enlargement of flocs.

6. Rapid sand filter: To remove the remaining suspended particles and impurities from water after initial treatment process of clariflocculation, a rapid sand filter is needed.

7. Disinfection Unit: Since the source of water is raw water from river Ganga it has MPN/100ml of 1600 which is very high therefore disinfection unit is needed to treat the incoming water. Disinfection Unit will act as a final and effective barrier to address any potential microbial contamination that may have survived previous treatment stages.

Chapter 5

Work distribution

Phase	Work	Timeline
Phase 1	Submission of first proposal report	4 August 2023
Phase 2	Design of Intake tank: Bwenyele Tep Design of Aeration unit: Akansha Mishra Design of Clariflocculator: Sonali Madhesia	8 September 2023
Phase 3	Design of Rapid Sand Filtration: Akansha Mishra Design of Clear Water Reservoir: Sonali Madhesia Design of Disinfection Unit: Bwenyele Tep	10 November 2023

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