WASTE WATER TREATMENT IN METRO RAIL STATIONS BY FLUIDIZED AEROBIC BED REACTOR

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CERTIFICATE

Certified that **Velmurugan.P** (1170470011) has carried out the research work presented in this Project entitled "**Wastewater treatment in metro rail stations by Fluidized Aerobic Bed (FAB) reactor"** for the award of **Masters of Technology in Civil Environmental Engineering** from Babu Banarasi Das University, Lucknow under my supervision. The Project embodies results of original work, and studies are carried out by the student himself and the contents of the Project do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

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ABSTRACT

This research investigates the wastewater as a pollution source that originate from the Lucknow metro rail stations, and their impact on the groundwater resources and the socio-economic factors, and the possible measures to improve the situation. The purpose of this paper is to decorative a model of investigating the impact of waste water from Lucknow metro rail stations, to recommend a treatment method of those and to study the effect of the treatment of the wastewaters disposed in common sewer drains.

Wastewater treatment is a process that is vital to protecting both the environment and human health. Implementing wastewater treatment by Fluidised aerobic Bed Reactor (FAB) processes in Lucknow metro stations will help us to manage and reduce the fresh water usage within the metro stations. At present, the most cost-effective way of treating wastewater is with Fluidised aerobic bed reactor. However, population increases have created a demand for more efficient means of wastewater treatment. Due to its high efficiency, the FAB reactor can also be used to treat wastewaters with high organic solid concentrations, which are more difficult to treat with conventional methods because they require longer residence times; the FAB reactor can also be used to reduce the system size and footprint. In addition, it is much better at handling and recovering from dynamic loadings (i.e., varying influent volume and concentrations) than current systems. Overall, the FAB reactor has been shown to be a very effective means of treating wastewater, and to be capable of treating larger volumes of wastewater using a smaller reactor volume and a shorter residence time. In addition, its compact design holds potential for more geographically localized and isolated wastewater treatment systems.

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LIST OF SYMBOLS AND ABBREVIATIONS

BOD	_	Biochemical Oxygen Demand
COD	_	Chemical Oxygen Demand.
STP	_	Sewage treatment plant.
LWSU	_	Lucknow Water State Utility
KLD.	_	Kilo Litre per Day.
MLSS	_	Mixed liquor suspended solids
PPM	_	Parts Per Million.
TSS	_	Total suspended solids.
FAB	_	Fluidized aerobic bed reactor.
CGWA/B	_	Central Ground Water Authority/ Board
HRT	_	Hydraulic Retention Time
TDS	_	Total dissolved solids
Ph	_	power of hydrogen
RO	_	Reverse Osmosis
KM	_	Kilometre
MLD	_	Million Litres per Day
Mbgl	_	meters-below ground level
DWLR	_	Digital Water Level Recorder
LPM	_	Live Partition Mobility
HVAC	_	Heating, ventilation, and air conditioning
WHO	_	World Health Organization
STP	_	Sewage treatment Process/plant
LPCD	_	Litres per Capita per Day

CHAPTER 1

INTRODUCTION

1.1 METRO RAIL SYSTEMS IN INDIA

Infrastructure plays a vital role in metropolis. Explosive growth of cities in developing countries and, thus the demand for improved liveability and environmental protection has created a strong demand for new underground development. India is also not excluded from urbanization issues. Based on the number of urban density and urbanization the urban development in India is growing rapidly. It means the consideration for using urban underground space for development must be given a full attention. Underground utilization pattern varies in different urban contexts, depending on the local culture, geographical situation, social environment and economic needs.

For some of us living in big cities, imagining our lives without the Metro would be difficult. The method of transport allows us to travel major distances much faster while simultaneously helping us skip the road traffic and greater exposure to pollution. When compared to private automobiles, this mode of transportation is also quite affordable. Based on all these reasons, the popularity of the Metro rail has gone up significantly. Little wonder then that we find it quite hard to push ourselves inside of the coaches during peak hours, especially in Delhi. People seem not to mind the rush since the advantages of travelling in a Metro far exceeds the inconvenience. This is why “easy access to a Metro network” is often cited as a unique selling point by developers while marketing real estate projects. Such significant has been the growth of this network that the government last year formulated with a Metro Rail Policy, 2017, with an aim to speed up work and tame cost overruns.

The metro rail system was introduced in major cities to relief the pressure from the surface, provide more efficient and encourage more extensive use of public transport. Metro rail system is having very high investment cost but the overall life cycle cost of underground metro system is very less. India is a developing country, new metro systems is being developing in the major cities of India such as Delhi, Bangalore, Chennai, Hyderabad, Kolkata, Lucknow, Mumbai etc.

Now a day, the commuters in metro rail system being gradually increased but at the same time, sanitation becomes very challengeable one. To maintain the hygienic environment in a metro station, huge amount of water being used for cleaning and sanitation like in toilets, hand wash area, etc.

1.2 FLUIDISED AEROBIC BED REACTOR

Fluidized aerobic bed reactor (FAB) can be an efficient alternative solution in advanced water treatment processes. It has been found promising to use fluidized bed reactor for wastewater treatment procedures. Fluidised Aerobic Bed Reactor (FAB) as the name indicates consists of floating media of cylindrical shapes and different sizes. As compared to conventional technologies FAB reactors are compact, energy efficient and user friendly. Implementing wastewater treatment by Fluidised aerobic Bed Reactor (FAB) processes in metro stations will help us to manage and reduce the fresh water usage within the metro stations. FAB Reactor is best suitable when designing a new waste water treatment plant, where operating cost & space are constraints. Upgrading of existing waste water treatment plants. Operate plants in low temperature areas.

1.3 THE OBJECTIVES AND AIMS

The main objective of the study is to investigate and specify the impacts of the huge quantity of raw wastewater to flow from metro rail stations on public drains and to reduce the groundwater or public water utilities, as well as the socio-economic factors, and possible measures to improve the situation. On the other hand, this study aims to:

- Fill the gap regarding the lack of the environmental studies about the study area;
- Assist the decision-makers to make the right decisions related to the current situation in the metro station region, based on the main results of this study.

Determining the water demand of the Lucknow city, as well as the wastewater hydro-chemical characteristics in the drainage basin will help in introducing the adequate protective approaches to improve the water sources by recycling with Fluidised aerobic bed reactor treatment system.

1.4 METHODOLOGY

Two data sources have been identified for this research, namely; primary and secondary data resources. The primary data are extracted mainly from the direct observations from the study area. The primary data used are conceptual and provides visions for the future, it is also informatics and helps to understand the current situation. Meanwhile, the secondary data are built through circulations of the available data in the forms of archived researches, literature reviews, published documents, mapping, and interpretation. Mainly the methodologies of data collection classified according to the aspects to be investigated in this thesis research are the quantity of wastewater drained out from metro stations and ground water or public water source (fresh water) utilized on daily basis randomly at metro stations and the Socio-economic aspects. The methodology of ground water level assessment consisted of two samplings for the study area: in order to evaluate the different trends of water and wastewater quality during the two periods regarding the chemical, physical and biological composition. The wastewater samples were collected from metro stations manually in 1-Litre and analyzed for pH, TDS, TSS, COD and BOD parameters.

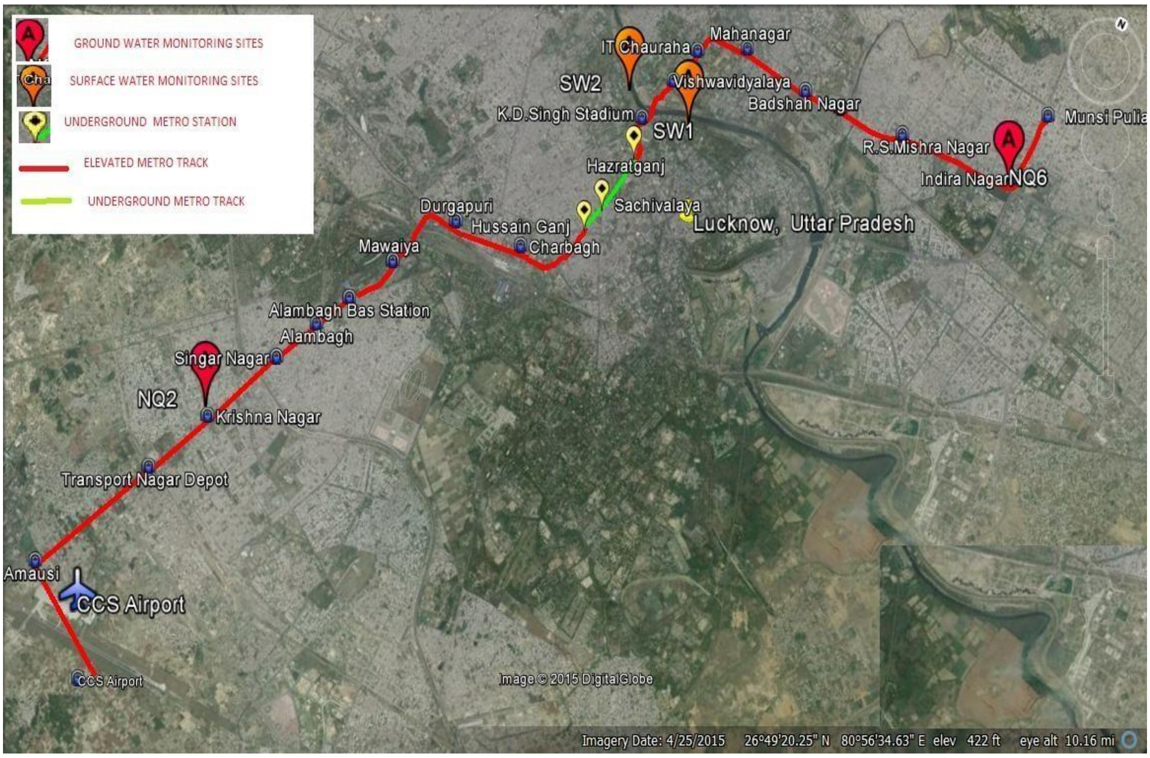

Fig 1.1 Water sampling locations (Source: Google Map, 2019 – Edited)

1.5 THESIS STRUCTURE

This research thesis consists of seven chapters, by which the effects of water source left without treating and recommending for fluidized aerobic bed reactor for waste water treatment in metro rail stations.

1.5.1 Introduction

This chapter presents the precursory background that introduces for the following contents of the research; it recognizes the scope and level of intervention of the research. Moreover, it clearly identifies the problem statements, the research hypothesis, goals and methodology, and systematically itemized on research theme and context.

The analysis of the study area (Lucknow metro rail stations), and the specified influenced localities (Krishnanagar, IIT Chauraha, Vishwavidayalay and Indranagar) in terms of their physical, geo- political, economic, environmental and other characteristics.

1.5.2 Literature Review

This chapter provides a survey of the existing literature about the subject of the research, it discusses the definition of the wastewater, previous studies about the impact of wastewater on fresh water quality, public health and environment, and finally the possible wastewater treatment processes, based on three hierarchical levels: global, regional and local levels.

1.5.3 Methodology

This chapter uses the adopted methodology to determine the wastewater treatment by fluidised acerbic bed reactor instead of other conventional methods (Like Sediment tank, RO etc.) and parameters of the wastewater and effluent, and to evaluate the suitability of the water resources for domestic uses.

1.5.4 Results and Recommendations

The closing chapter briefly checks the ability of the research to achieve its goals. It also provides a general policy framework of strategies, for promoting results and a proper wastewater treatment plant (Fluidized aerobic bed reactor) in order to mitigate the catastrophic effects of the wastewater in the metro stations.

1.5.5 Conclusions and Recommendations

Based on the result, this can help in applying the sustainable development concept and converting these negative effects of the wastewater into water reuse and other purposes by identifying the preconditions to initiate such development, through a brief discussion for the generalization ideas and recommendations for policy making to adopt FAB technology.

References

Includes a complete listing of all resources cited in the thesis.

1.6 STUDY AREA

1.6.1 LUCKNOW METRO RAIL (PROJECT HIGHLIGHTS)

Lucknow is popularly known for its cultural and intellectual traditions as well as its current status as a nucleus of service industry, education & research. Lucknow is the capital of Uttar Pradesh & administrative headquarters of Lucknow district & division. With its 2.2 million inhabitants Lucknow Urban Agglomeration has currently over 3 million populations. The master plan has projected a population of about 3.2 million and 4.0 million by years 2011 & 2021 respectively. Being an important cultural and trading centre Lucknow continues to grow and attract large number of people to the city. The rapid growth of the city and the associated urban sprawl has accentuated the demand supply mismatch amidst the constrained transport infrastructure resulting in economic and social externalities. The need for a well-developed legal mechanism to conserve resources, protect the environment and ensures the health and wellbeing of the people in India was felt. Keeping the pace with international laws, the Ministry of Environment and Forest enacted Environmental Protection Act in 1986. Over the years, the Government of India has framed several policies and promulgated number of Acts, Rules and Notifications aimed at management and protection of the environment. During last three decades an extensive network of environmental legislation has grown and presently it has a fairly complex body of environmental legislation aimed at ensuring that the development

Lucknow Metro, the dream project of the people of Lucknow, is progressing at a very fast pace and has already achieved the distinction of being the fastest Metro project execution that has ever been undertaken in the country. This metro alignment current phase is located in Lucknow on North- South Corridor between Airport (Charan Singh) and Munishipulia. The alignment would serve the area by providing better connectivity to people coming from and going to the rural area between Barabanki and up to Faizabad. The maintenance Depot is also available at transport nagar. This metro corridor is to cater the requirement of the city for a length of about 27.5 Km. The total corridor covers elevated (24 Km) and underground (3.5 Km) respectively and 24 stations.

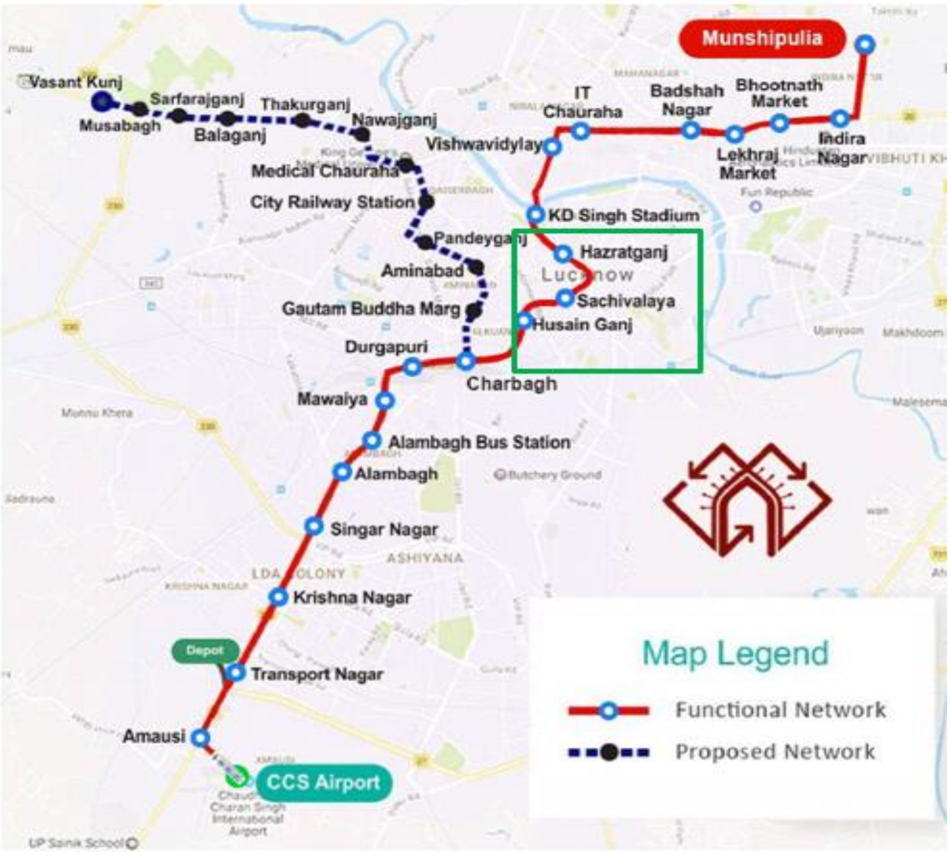

Fig. 1.2. Lucknow metro project routes

1.6.2 WATER AND WATER POLLUTION

The use of water resources and also the discharge of polluted water (wastewater) are primarily regulated by the Water (Prevention and Control of Pollution) Act, 1974 amended in 1988. The Water Cess Act, 1977 amended in 1992 and 2003, including Rules 1978 and 1991 provides for levy and collection of Cess on water consumed with a view to generate resources for prevention and control of water pollution. The Act assigns functions and powers to the Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCBs) for prevention and control of water pollution. The Environment (Protection) Act 1986 amended in 1991 and Rules also lays down specific standards for quality of water effluents to be discharged into different type of water bodies (sewers, surface water bodies like lakes and rivers, marine discharge). Additionally, the water supplied to users for drinking shall also conform to the National Drinking Water Standard. Off late, with rapid depletion of groundwater resources in several areas of the country, efforts have been initiated to regulate the use of groundwater resources. The focus of such acts and rules is to provide for mechanisms that would lead to replenishment of groundwater reserves through techniques like rain water harvesting. The Central Ground Water Board, (CGWB) the statutory authority set up by the Central Government has also restricted the drilling of tube wells and bore wells in certain water scarce areas in the country.

1.6.3 GROUND WATER DEPLETION (LUCKNOW- Underground water stress)

Water is treated as one of the most essential of all natural resources for the survival of life on the Planet. In the present scenario, potable fresh water and its availability has assumed critical dimensions both in term of quality and quantity.

As demand of ground water resource is increasing, its overall availability is also diminishing. The resource is depleting at faster pace and in future will become a critically scarce resource, particularly in urban sprawls. Hence, it becomes essential to manage and utilize this natural resource more efficiently. The present report highlights the urban ground water issues focusing the critical status of ground water in Lucknow city. The report gives a picture of ground water in the city which shows how the resource is depleting and which are the critical areas. In Lucknow city, river Gomti has been the main source for drinking water, but now 70% of municipal water supplies are dependent on ground water, making it a predominant source for city's water supplies. This clearly reflects the vital position ground water has attained in urban water system, despite the fact that this resource is depleting fast within the transforming concrete environment of Lucknow.

Apart from large scale ground water exploitation for city's municipal water supply, the residents of Lucknow, with the mindset to have alternative & secured water supplies, generally prefer to have own tube well and with this attitude, private tube well construction activities have gone up in multiple proportion and as a result the city has mushroomed with innumerable private tube wells/domestic borings to an extent which has led to intensive & unregulated extractions, but there is no realistic estimate of such unregulated withdrawals which are responsible for the present day ground water crisis.

As demand of ground water resource is increasing, its overall availability is also diminishing. The resource is depleting at faster pace and in future will become a critically scarce resource, particularly in urban sprawls. Hence, it becomes essential to manage and utilize this natural resource more efficiently.

But, as the unscientific & unregulated ground water extraction in urban centres is almost reaching to unsustainable levels, the emerging situation is very disturbing. Especially, in the absence of effective management interventions, the impact may be extremely grave for the urban environment of the state and therefore, the rapid depletion of urban aquifers may reach to an irreversible stage. Presently, there are no authentic studies on urban ground water. therefore, the imperative need is to evolve some useful plans and strategies for suitably managing, protecting & conserving the depleted urban aquifers in order to make them sustainable for future ground water extraction.

STATUS OF LUCKNOW CITY'S WATER SUPPLY

Since 2005, with rapid urban expansion and significant decline of ground water levels to the extent of 0.5m to 1.0m per year in most of the city area, tube wells construction activity/re-boring is continuously going on, despite reduced yields and increased withdrawals.

a) Demand: 525 MLD.

b) Total Production: 675 MLD.

c) Surface water based: 280 MLD (from Aishbagh, Balaganj & Gomtinagar water works)

d) Ground water based: 395 MLD.

(Source: From report of Ground Water Department, U.P-2015).

Apart from large scale ground water exploitation for city's municipal water supply, the residents of Lucknow, with the mindset to have alternative & secured water supplies, generally prefer to have own tube well and with this attitude, private tube well construction activities have gone up in multiple proportion and as a result the city has mushroomed with innumerable private tube wells/domestic borings to an extent which has led to intensive & unregulated extractions, but there is no realistic estimate of such unregulated withdrawals which are responsible for the present day ground water crisis. As per estimates, the possible ground water withdrawals in the city from both the municipal & private systems are extremely high which may be tentatively taken as 750 million litres per day (MLD) or more.

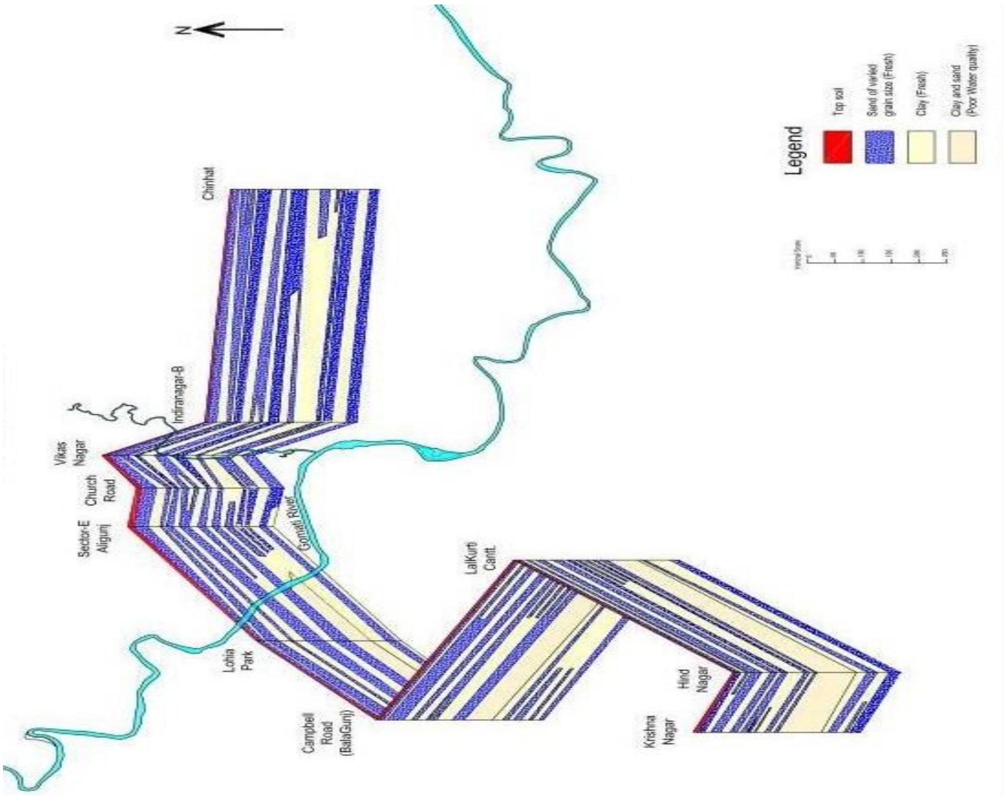

Fig-1.3 Three Dimensional View of Ground water based on Bore hole logs in Lucknow City ((Source: From report of Ground Water Department, U.P-2015).

GROUND WATER LEVEL DECLINE AND ITS IMPACT

- In the 1970s, the pre-monsoon depth to water table in Lucknow city was less than 10 mbgl for the most part, which was even shallower along the flood plain of Gomti.
- With continuous large scale withdrawals, today the ground water table has depleted widely beyond the depth of 20 mbgl and even crossed much deeper levels i.e. 30m bgl or more in some areas, including Lalbagh, Cantt, HAL, Indira Nagar, Alambagh, Vishwavidyalaya.
- As a result, a through (depressed area) has developed within the ground water regime of the city, indicative of heavily depleted aquifers in the city.
- This situation has further aggravated at some places, where ground water level depth has reached to a more critical level, i.e. beyond 40m. These places are Babu Bhawan, Cantt Sadar, Maunibaba.
- The emerging situation of ground water levels is very alarming, as such areas seems to have reached to an irreversible stage.

DATA ANALYSIS AND FINDINGS

The ground water levels are being monitored by the department through a close network of Piezometers installed during 2006 in the city's area. CGWB is also monitoring water levels in Lucknow city since 2003. In majority of the piezometers, decline in ground water level has been significantly observed. Some piezometers are showing relatively much faster decline that are located in Gomtinagar, Lalbagh, HAL, Alambagh, Krishnanagar, IIT Chauraha, Vishwavidyalaya, where more than 5 metres of decline has been recorded in a span of 4 years. This rapid depletion may be attributed to metro project on this stretch and minor constructions as well as the heavy pumping going on in the area. **Ground Water Level at Bapu Bhawan.** Ground Water level measured through DWLR is as follows:

- January, 2015: 39.55 mbgl
- December, 2018: 41.2 mbgl.

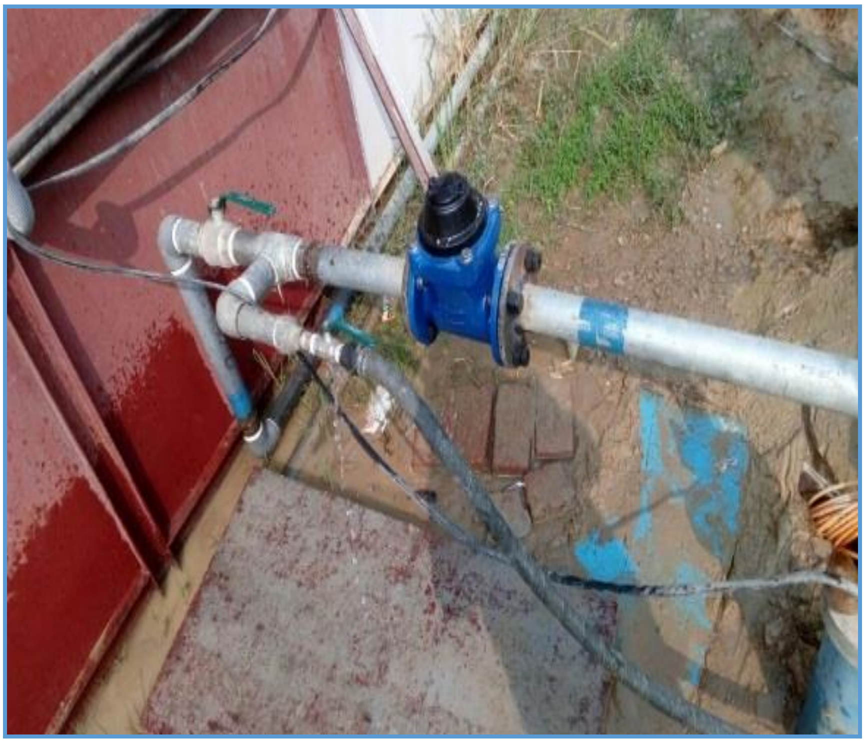

Fig 1.4 Location: IIT Chuaraha & Charbagh-Digital Water level recorder for underground water source (Source Field study)

The consequences of water-table decline go beyond tube well yield reductions to include:

The Gomti River changing from 'effluent condition' (gaining flow from natural groundwater discharge) to 'influent condition' (losing flow to groundwater infiltration) – which gives rise to concern about groundwater pollution from polluted river-water and lack of flow for dilution of sewage discharges much greater constraint on the use of surface-mounted centrifugal pumps for tube well pumping and general need for much more expensive pumping equipment although there are no reports of significant groundwater-extraction related land subsidence. Thus it is considered that the only robust way to face the future urban water-supply challenge is to look towards a more integrated and harmonised conjunctive use of surface water and groundwater sources. Tube well yields have reduced significantly. Data shows that in Municipal tube well yields have reduced from 1500 LPM in seventies to 600-800 LPM currently. This is direct manifestation of depleting aquifers & water level lowering. The declining ground water levels have changed the condition of Gomti River from effluent (gaining flow from natural ground water discharge) to influent (losing flow to ground water infiltration).

Fig 1.5 Location: Charbagh Waste water sample collection (Source -Field study)

Table 1.1 Groundwater level data of Lucknow City (Source: Field study)

S.No.	Location of Piezometer	Pre Monsoon 2018 (mbgl)	Decline/Rise between Pre 2014 & 2018 (mbgl)	Post Monsoon 2018 (mbgl)	Decline/Rise between Post 2014 & 2018 (mbgl)
1	Airport	14.85	0.00	15.35	-1.34
2	Alambagh	34.75	-5.19	35.05	-5.85
3	Charbagh	42.80	-4.46	43.25	-4.15
4	Gomati Nagar	26.95	-7.15	27.85	-8.20
5	IIT Chauraha	18.60	-4.20	19.05	-3.85
6	Indira Nagar	28.15	-3.25	28.95	-4.75

1.6.4 WATER ENVIRONMENT IN METRO STATIONS

Water environment consists of water resources and its quality. Its study is important from the point of view to assess the sufficiency of water resources for the operational stage and also to assess the impact on water environment. In the metro stations, ground water and LWSU is being used as post construction period; hence its quality has been tested to evaluate its suitability for the intended purpose. Anticipated impacts of the proposed project on water environment have also been addressed. The hydro-geological situation characterized by occurrence of alluvial formation and quarzitic weather rocks controls the availability of groundwater. It is estimated that ground water availability in Lucknow is 292 Mm^3. Salinity and over exploitation have contributed to depletion and drastically affected the availability of water in different parts of the city.

This diagnosis of groundwater resource status and strategic planning needs now requires critical review and complementary investigation to consolidate a long-term sustainable groundwater use policy. In addition, and most importantly, an appraisal of institutional roles in relation to urban groundwater is needed, with consideration of institutional mechanisms to incorporate groundwater issues into urban infrastructure decision-making.

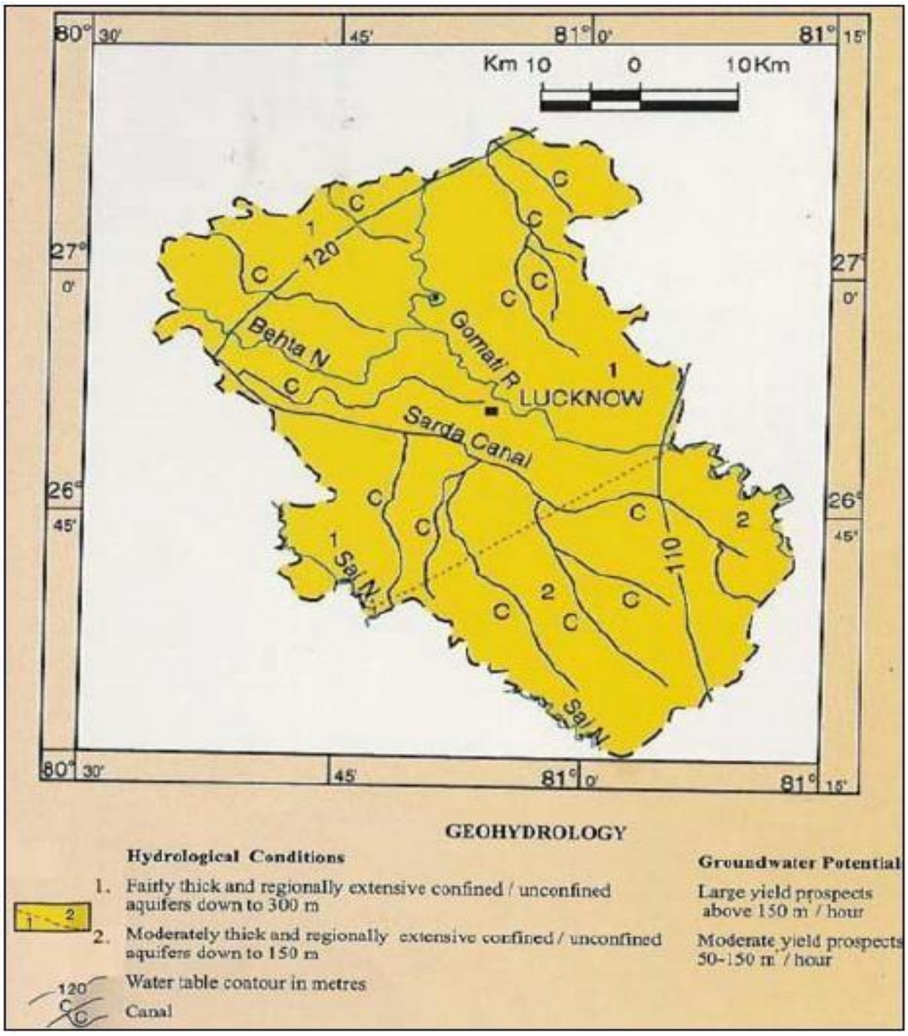

Fig 1.6 - Geo Hydrological Map of the Lucknow District

It should be noted, however, that because of the long-term availability of local groundwater resources the municipal water-supply position in the LWSU is considerably better than that in most cities of peninsula India for example – and that the current problem is as much one of distribution system constraints (caused by rapid and unplanned growth) as it is one of absolute resource shortage.

Table 1.2: Summary of the historical evolution of LWSU groundwater supply

Year	1985	2005	2012	2016	
No. of tube wells	45		70	300*	500*
Typical tube well depth(m)	120		120	200**	200**
Well-screen depth(m)		70 - 120		90-140/100-200***	
Aquifer productive level tapped	II		II	II (III)**	II (III)**
Typical tube well yields (l/s)		20 - 25		10 - 20	
Total municipal groundwater supply (Ml/d)	50		70	190	240

* approximate total number but at any one time some (around 10%) being reconditioned or replaced

** some tube wells drilled to 350m depth so as to tap third aquifer productive level

*** difference between cis-Gomti and trans-Gomti areas because of occurrence of saline groundwater

1.6.5 WATER QUALITY

Water quality is the physical, chemical and biological characteristics of water. It is most frequently used with reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to drinking water, safety of human contact, and for health of ecosystems. An understanding of the various factors influencing water quality is thus very important as human health is largely dependent on the quality of water available for our use. Ground water (Two locations) and surface water (Two samples) samples. Were collected from the study area to assess the water quality during the study period. The ground water samples were drawn from the bore wells. Surface water sampling was carried out from the Gomti River.

The test results when compared with the prescribed limits of various parameters as per IS 10500:1991 indicated that the total hardness and alkalinity of Indira Nagar water exceeding the desirable limits but within the permissible limits. The remaining parameters of the samples were within the desirable limits. The details of the sampling locations are given in Table 1.3 and shown in Figure 1.1. The results of ground and surface water samples are provided in Table 1.3 and 1.4.

Table 1.3 Water sample locations (Source: Field study)

S.No.	Code	Name of the sampling Location
1	GW1	Indira Nagar
2	GW 2	Krishna Nagar
1	SW1	Gomti River (Upstream)
2	SW2	Gomti River (Down Stream)

Table 1.4 Ground water quality at bore wells

Parameter	Unit	Location Krishnanagar	Location IIT Chauraha	Location Indira nagar	Drinking Water Standard	
					Desirable	Permissible
pH Value	--	7.47	7.57	7.64	6.5	8.5
Total Hardness as $CaCO_3$	mg/l	399.36	258.23	276.48	300	600
Total Dissolve Solids	mg/l	460	418	434	500	2000
Alkalinity as $CaCO_3$	mg/l	253.44	289.32	372.48	200	600
Iron as Fe	mg/l	0.25	0.17	0.19	0.3	1.0
Chlorides as Cl	mg/l	103.66	28.59	30.59	250	-
Nitrate as NO_3	mg/l	18.8	3.8	4.0	45	-
Phosphate as PO_4	mg/l	0.15	0.19	0.20	-	-
Arsenic as As	mg/l	<0.01	<0.01	<0.01	0.05	-
Lead as Pb	mg/l	<0.005	<0.005	<0.005	0.05	-
Chromium as Cr+6	mg/l	<0.1	<0.1	<0.1	0.05	-
(Source: Field Studies) Month of Monitoring: December 2018						

Table 1.5 Surface water quality

Parameter	Unit	Gomti River Upstream	Gomti River Downstream
pH Value (at 28°C)	--	7.55	8.28
Temperature	^{0}C	32	32
Oil & Grease	mg/1	<1.4	<1.4
Total dissolve solid	mg/1	294	305
Total Suspended Solid	mg/l	31.4	17.2
Iron as Fe	mg/1	0.80	0.56
Chlorides as Cl	mg/1	29.7	25.5
Nitrate as NO3	mg/1	14.0	14.52
Phosphate as PO4	mg/1	0.60	0.53
Lead as Pb	mg/1	<0.005	<0.005
Chromium as Cr+6	mg/1	<0.1	<0.1
Chemical Oxygen Demand	mg/1	7.36	11.04
Biochemical Oxygen Demand, 3 days at 27°C	mg/1	<2.0	3.4
D.O. At 29°C	mg/1	4.08	4.1
Total Coliform	MPN/100ml	1600	1600
(Source: Field Studies) Month of Monitoring: December 2018			

1.6.6 REGIONAL SCENARIO (Lucknow)

The pH limit fixed for drinking water samples as per IS: 10500 is 6.5 to 8.5 beyond this range the water will affect the mucus membrane and or water supply system. As per the monitoring results, the pH was varying for ground water from 7.47 to 7.64 and in Surface water the pH was ranging from 7.55 to 8.28 which were found to be within the limits. The desirable limit for total dissolved solids as per IS: 10500 are 500 mg/l whereas the permissible limits in absence of alternate source are 2000 mg/l, beyond this palatability decreases and may cause gastro intestinal irritation. In ground water samples collected from the study area, the total dissolved solids are varying from 276.48 mg/l to 399.36 mg/l. In surface water the total dissolved solids were varying from 294 mg/l to 305 mg/l. The TDS of all the samples were found to be within the desirable limits.

1.6.7 METEOROLOGY DATA

Lucknow has an extreme climate, which is very cold in winter and hot in summer. The climatic conditions in project area are characterized by a rainy season (July-October), winter (November-March) and summer (April-June). Over 75% of the rainfall is received during rainy season. The cooler season from December to February is followed by the summer season from March to June. The period from June to about the end of September constitutes the south-west monsoon season, and October and November form the post-monsoon season. The average number of rainy days is 44. The normal rainfall of Lucknow district is 966.24 mm. The maximum rainfall occurs during the monsoon period i.e. June to September having normal value of 849.78 mm which is 87.9% of the annual rainfall. July is the wettest month having the normal rainfall of 289.56 mm followed by August with normal rainfall of 287.66 mm. ***(Source: Indian Meteorological Department).***

1.6.8 WATER POLLUTION, WATER SUPPLY AND SANITATION IN METRO STATIONS

Public Health facilities such as water supply, sanitation and wash rooms are very much needed at the stations. The water demands will be on station for drinking, toilet, cleaning and also for other purpose like HVAC, chiller, train coach washing, maintenance, repair work and other purposes. Water shall be treated before use, up to WHO drinking water standards. Ground water or tube wells are the source of water used for this purpose.

1.6.9 WATER RESOURCES

In the thesis following were considered in terms of precipitation, surface run off; quantity and quality of water. The water requirement for the stations met through the public water supply system (Lucknow Water-Supply Utility-LWSU) and tube bore wells at each stations.

1.6.10 WASTE WATER TREATMENT

Waste water is the water that emerges after fresh water used by human being for domestic control and industrial use. This thesis will restrict itself only to the waste water generated due to domestic use. By and large, it is fresh water that is used for a variety of domestic uses such as washing, cleaning, flushing toilets This water is referred to as grey water or sullage.

Water used for flushing toilets to evacuate human excreta is called black water or waste water. Waste water contains all dissolved minerals present in the fresh water that uses and becomes waste water as well as all other contaminants as proteins, carbohydrates, oil fats. These contaminants are degradable and use up oxygen in the degradation process. Therefore, these are measured in terms of their demand for oxygen which can be established by certain tests in laboratory. This is called Bio degradable oxygen demand (BOD}. Some chemicals which also contaminate the water during the process of domestic use also degrade and use oxygen and the test done to establish this demand which is called chemical oxygen demand (COD). Waste water also contains coli form bacteria (ecoli) which is harmful to human being. Another feature of waste water is the high level of total suspended solids (TSS). This is what give the waste water black colour, hence the name black water, if the cloudy water is allowed to reach the lakes and rivers, it blocks the sunlight from reaching the bottom of water body. Waste water is hazardous to the environment and human being if raw waste water disposes off to mix in to the ground water or other water bodies causes diseases.

The major aim of the waste water treatment is to remove as much of the suspended solids as possible before the remaining water, called effluent is discharged the environment. Treated waste water to ported public health prevent disease causes environment, prevent pollution of water bodies and can be reused in flushing or horticulture purposes. We consider wastewater treatment as water use because it is so interconnected with the other uses of water. Much of the water used by homes, industries, and businesses must be treated before it is released back to the environment. If the term "wastewater treatment" is confusing to you, you might think of it as "waste water treatment." Nature has an amazing ability to cope with small amounts of water wastes and pollution, but it would be overwhelmed if we didn't treat the billions of gallons of wastewater and waste water produced every day before releasing it back to the environment. Treatment plants reduce pollutants in wastewater to a level nature can handle. Wastewater is used water. It includes substances such as human waste, food scraps, oils, soaps and chemicals. In homes, this includes water from sinks, showers, bathtubs, toilets, washing machines and dishwashers.

Why Treat Wastewater?

It's a matter of caring for our environment and for our own health. There are a lot of good reasons why keeping our water clean is an important priority:

- *Fisheries* - Clean water is critical to plants and animals that live in water. This is important to the fishing industry, sport fishing enthusiasts, and future generations.

- *Wildlife Habitats* - Our rivers and ocean waters teem with life that depends on shoreline, beaches and marshes. They are critical habitats for hundreds of species of fish and other aquatic life. Migratory water birds use the areas for resting and feeding.
- Recreation and Quality of Life - Water is a great playground for us all. The scenic and recreational values of our waters are reasons many people choose to live where they do. Visitors are drawn to water activities such as swimming, fishing, boating and picnicking.
- *Health Concerns* - If it is not properly cleaned, water can carry disease. Since we live, work and play so close to water, harmful bacteria have to be removed to make water safe.

Effects of wastewater pollutants

If wastewater is not properly treated, then the environment and human health can be negatively impacted. These impacts can include harm to fish and wildlife populations, oxygen depletion, beach closures and other restrictions on recreational water use, restrictions on fish and shellfish harvesting and contamination of drinking water. Some examples of pollutants that can be found in wastewater and the potentially harmful effects these substances can have on ecosystems and human health:

- Decaying organic matter and debris can use up the dissolved oxygen in a lake so fish and other aquatic biota cannot survive;
- Excessive nutrients, such as phosphorus and nitrogen (including ammonia), can cause eutrophication, or over-fertilization of receiving waters, which can be toxic to aquatic organisms, promote excessive plant growth, reduce available oxygen, harm spawning grounds, alter habitat and lead to a decline in certain species;
- Chlorine compounds and inorganic chloramines can be toxic to aquatic invertebrates, algae and fish;
- Bacteria, viruses and disease-causing pathogens can pollute beaches and contaminate shellfish populations, leading to restrictions on human recreation, drinking water consumption and shellfish consumption;
- Metals, such as mercury, lead, cadmium, chromium and arsenic can have acute and chronic toxic effects on species.
- Other substances such as some pharmaceutical and personal care products, primarily entering the environment in wastewater effluents, may also pose threats to human health, aquatic life and wildlife.

1.6.11 INCREASED WATER DEMAND

The water demand will increase during regular cleaning, flushing's, routine works and domestic water requirement for commuters using metro stations. Sufficient water made available by LWSU as it is responsible for water supply in Lucknow. Water requirement for Metro stations met through this public supply. The fresh water supplied by LWSU for the purpose of fulfilling the water needs of metro station and therefore after usage, 75% raw wastewater are drained into common sewer lines mostly. Proper attention not taken while draining the wastewater in public drains and gives negative impact on the residents living in the vicinity of the metro rail stretch. Thus, there would be total water requirement of 100 KLD per metro station and therefore 2400 KLD (24 Metro stations at presently) for the entire Lucknow metro stretch per day.

1.7 WASTEWATER EFFECTS ON SOCIO-ECONOMIC ASPECTS

1.7.1 INTRODUCTION

The analysis for the socio-economic effects of wastewater in the study area, to achieve this purpose the research based on a field survey by which a questionnaire prepared and filled by a random sample of the study area residents. The assessment attempts to predict and evaluate the future impacts of project upon people, their physical and psychological health and wellbeing, their economic facilities, cultural heritage, lifestyle and other value system. The information related to demography and socioeconomic profile of the population of study area has been collected from the census report of 2011 and other governmental sources. Potential impacts on water environment by metro stations are primarily related to water consumption and disposal of wastewater. The quantitative assessments, carried out separately for operational phase of metro rail, will form the basis for the development of Environment and thereby facilitate in minimizing or eliminating impacts on the water environment of the region.

1.7.2 QUESTIONNAIRE MAIN COMPONENTS

The questionnaire questions have been classified according to four main components, affected by wastewater within the study area, which could be listed as follows:

- The effects of wastewater on livestock (economic)
- The effects of wastewater on natural and aesthetic wealth (environmental).
- The effects of wastewater on social aspects (social).

1.7.3 RESULTS AND DISCUSSIONS

This part of the chapter clarifies the analysis of the questionnaire results, divided into four sections: General, health, socio-economic and the environmental sections.

1.7.4 THE GENERAL SECTION

- **Geographical Distribution**

The total number of questionnaires divided equally among the two agglomeration, so that each has approximately equal number of questionnaires, which could guarantee homogeneous covered area table 1.6

Table 1.6: Geographical Distribution of Respondents

Community	No. of Questionnaires	Percentage (%)
Krishna Nagar	25	50.0
Indra Nagar	25	50.0
Total	50	100.0

- **Gender Composition**

Although Lucknow women play an important role in the management of the house hold water resources, only 30% of the respondents were females (Figure 4.1).

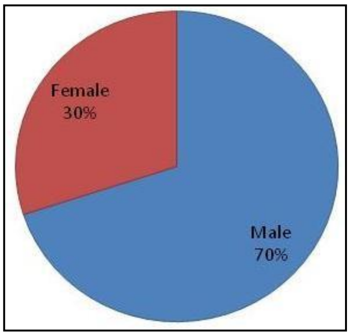

Figure 1.7: Gender Distribution of the Respondents

- **Occupation Type**

(Table 1.7) clearly indicate that a large proportion of the population (about 68%) do not have fixed jobs. Comparatively, 32 percent of the overall sample are employed by the governmental or the private sectors.

Table 1.7: Occupation of the Respondents

Community	**Occupation**				**Total**
	Governmental sector Employee	**Private sector Employee**	**Skilled work**	**Other**	
Krishna Nagar	24.0%	12.0%	40.0%	24.0%	100.0%
Indira Nagar	28.0%	4.0%	36.0%	32.0%	100.0%
Average	26.0%	8.0%	38.0%	28.0%	100.0%

1.7.5 SOCIAL SECTION

This significant impact has a wide range of negative results that affect all of people's life aspects; social, economic, healthy and environmentally. However, it is considered as the main impact of the study because it's huge influence on the main water sources for region which may lead to a serious catastrophe in the water sector. The majority of the respondents in both communities believe that raw wastewater has negative influences on ground water level. More than half of the respondents from Krishna Nagar reported having been affected by the depth of ground water level decreased as a result, while 33 percent reported the same in Indira Nagar. Most common social implications mentioned include bore well depth to be increased and yield level of bore well goes down yearly (Figure 1.8).

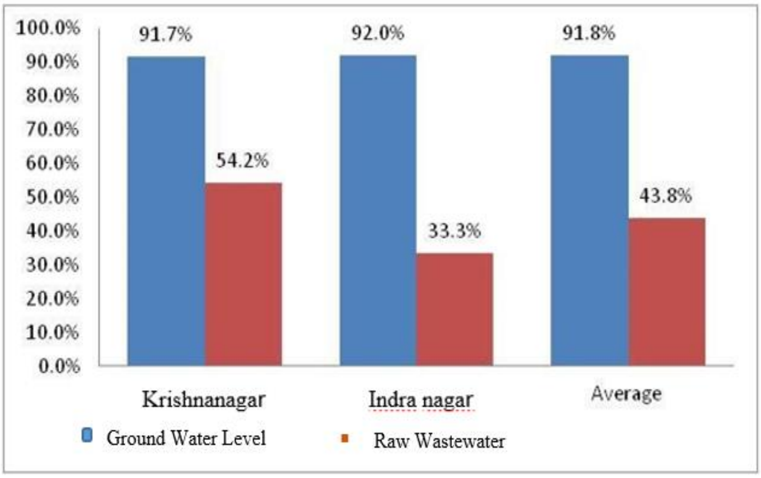

Figure 1.8: Impact and Proportions of Raw Wastewater In terms of public awareness, the questioner clarifies that much male respondents believe that the wastewater has a negative impact (Table 1.8).

Table 1.8: Gender Perceptions on Negative Impact of Wastewater Flow

Community	**Impact on**	**Diseases as a Result of Wastewater Flow**
Male	94.1%	51.5%
Female	86.7%	26.7%
Average	91.8%	43.8%

1.7.6 THE ENVIRONMENTAL SECTION

The majority of the respondents in the communities believe that the raw wastewater has negative impacts on the aesthetic conditions of the surrounding environment (Table 1.9).

Table 1.9: Impact of wastewater Flow on Aesthetic Condition

Community	Impact on the Aesthetic Conditions of the Study Area		Total
	Yes	No	
Krishna Nagar	80.0%	20.0%	100.0%
Indira Nagar	92.0%	8.0%	100.0%
Average	86.0%	14.0%	100.0%

1.8 NEED FOR THE STUDY

The need of the study is to improve the waste water treatment and reuse the treated effluent in the metro stations of Lucknow by using fluidized aerobic bed reactor. Fresh water being used in metro stations for sanitation which needs alternative further to avoid water scarcity in the Lucknow city. So treated effluent can be reused in all washrooms, toilets, plantation works, etc. But conventional wastewater treatment plants working that are large-sized, power intensive and require a lot of monitoring. So Fluidised Aerobic Bed-Reactor (FAB), the space and power saving technology is a better alternative to conventional wastewater treatment plants. This alternative can meet a sustainable wastewater management requirement in underground Metro stations and has a promising future, especially for developing country like India. Fluidized bed reactor (FAB) can be an efficient alternative solution in advanced water treatment processes in metro stations. In line with our endeavour to introduce latest technologies related to Water & Waste water treatment, Ion Exchange has developed a Fluidized Bed Reactor using attached growth process for Waste water treatment.

1.9 OBJECTIVES OF THE STUDY

The objectives of the study are as follows:

- To treat all waste water in the metro station prior to disposal for recycling.
- To reuse the treated effluent in all possible situations in the Metro stations.
- To reduce the fresh water utilization in sanitation works
- To minimize the public water supplies.

CHAPTER 2

REVIEW OF LITERATURE

1. **Jeris, J. S. (1983).**

   A pilot plant result of aerobic treatment using granular biological fluidized bed treatment for a number of industrial wastes is presented. An energy comparison showed aerobic treatment to produce a positive energy balance compared to an energy need for comparable activated sludge treatment.

2. **Bull, M. A. et al., (1984).**

   At each influent strength, one fluidized bed reactor was operated as a single-phase system while the other was operated as a methanogenic reactor which was preceded by an acidification reactor in a separated phase system. The reactors were operated under steady-state and variable process conditions.

3. **Sanz, I., et al., (1990).**

   However, a great accumulation of TSS was observed in the top of the fluidized bed. At 10°C, and a hydraulic retention time of 1.5 h, 70% of COD removal was achieved.

4. **Iza, J. (1991).**

   A review of the theoretical basis for the design and operation of fluidized bed reactors for aerobic treatment of wastewaters is presented. A step by step design strategy, including media selection, operative conditions of the reactor, equipment sizing and long-term run effects, as well as mechanical design hints on distribution system, reactor body, piping of recycle lines and gas collection are included.

5. **Borja, R., & Banks, C. J. (1995).**

   The reactor was subjected to transient changes in temperature, pH, influent flowrate and COD for 6 and 12 h periods. The quality of the effluent deteriorated under these shock load conditions but returned to steady-state values within 6–16 h upon restoring normal conditions. The stability of the reactor under unfavourable process conditions is discussed.

6. **Wang, Z. (1995).**

The aerobic fluidised-bed system can be operated at a significantly higher liquid throughput than other previously reported systems while maintaining its excellent efficiency.

7. **Borja, R., & Banks, C. J. (1995).**

The differences were probably due to diffusion limitations and a less active biomass in the AF. In both reactors the gas production rate and the levels of organic acids increased in response to a higher feed concentration in less than one day and this could be explained by substrate limitation.

8. **Borja, R., et al., (1995).**

An aerobic fluidised-bed reactor for purification of wastewater was modelled as a continuous-flow, completely-mixed homogeneous microbial system, with the feed COD as the limiting-substrate concentration.

9. **Khodadoust, A. P., et al., (1997).**

The chemical oxygen demand (COD) loading to the reactor was increased several times as high as 63 g/kg of GAC (Granular activated carbon) per day using reactor empty bed contact times as low as 9.3 h.

10. **Garcia-Calderon, D., et al., (1998)**.

It was found that the main advantages of this system are: low energy requirement, because of the low fluidization velocities required; there is no need of a settling device, because solids accumulate at the bottom of the reactor so they can be easily drawn out, and particles with high-biomass content, whose specific density have become larger than 1000 kg m^{-3} can be easily recovered.

11. **Kaksonen, A. et al., (2003).**

With increased loading rates, high recycling rate became an advantage. After process failure caused by intentional overloading, the sulphate reduction partially recovered within 2 weeks.

12. **Medhat M. A. Saleh, (2004).**

The presence of biodegradable components in the effluents coupled with the advantages of aerobic process over other treatment methods makes it an attractive option.

13. RangasamyParthiban, et al. (2007).

The experimental protocol was defined to examine the effect of the maximum organic loading rate (OLR), hydraulic retention time (HRT), the efficiency of the reactor and to report on its steady state performance.

14. G. M. Shida et al., (2008)

Organic materials in the wastewater can be an inexpensive raw material for integrate fermentation process and supply renewable energy source such as hydrogen.

15. M.A. Stylianou et al.,

In the present study the use of natural zeolite as filling agent in fixed and fluidized bed reactors for the removal of heavy metals from aqueous solutions is investigated. However, in real conditions wastewater contain suspended solids and in this case the use of fluidized bed will lead to better results, as in the fixed bed clogging problems are expected to occur.

16. Haroun, M., et al., (2009).

A fluidized bed reactor (FAB) with activated carbon as support material has been used to investigate the removal efficiency of chemical oxygen demand (COD), biochemical oxygen demand (BOD).

17. Rajasimman et al., (2009).

In their investigations wastewater treatment using inverse fluidized bed bio reactor, (IFBBR) with low density polypropylene irregular shape inert media found that the COD removal efficiency of 94.3% could be achievable.

18. SitiRoshayu Hassan,et. al., (2013)

This paper reviews the development and evolution of aerobic reactor for wastewater treatment. The successful application of aerobic technology to the treatment of wastewater is critically dependent on the development and type of aerobic reactor used.

19. Farhana Tisa, et al., (2014).

Fluidized bed reactor (FBR) can be an efficient alternative solution in advanced water treatment processes. Fenton oxidation is popular among other advanced oxidation processes. FBR-Fenton process can reduce production of sludge in water treatment and also offers lower hydraulic retention time compared to other biological and chemical processes. This research work is an attempt to develop basic steps to design this FBR.

20. P. Saranraj and D. StellaIndustrial, (2014)

The challenge is to properly incorporate the disposal of the wastes in a controlled management programme so that the applied industrial solid wastes do not contribute any problem of pollution to soil, soil microbes and environment.

CHAPTER 3
METHODOLOGY

At presently, the waste waters are flushed out into the public sewer lines and no recycle systems (except sediment tanks) and fresh water make up carried on daily basis from Lucknow Municipal Corporation and tubed bore wells. Rapid urbanization, population growth and limited land availability increased the global issue of water crises and wastewater disposal method. In the present study, Fluidized Aerobic Bed reactor treatment (FAB) system based waste water treatment plant recommended scientifically. A separate long term & effective Water Reuse/Recycle treatment set up shall be prepared for implementation, envisaging suitable interventions for a more harmonized conjunctive use of surface and ground water. There should be a vision for planned conjunctive use to reduce the stress on ground water.

Fluidized aerobic Bed reactor is a process which is now widely applied in many industrial applications. In recent studies it is evident that, fluidized aerobic bed reactors can also be an attractive procedure for treating polluted water. Waste water that is generated from metro stations is highly recalcitrant and is hostile to environmental ecology and human lives. Biological and chemical processes have failed to convert the contaminants fully as, biological and chemical processes and degrade up to 60% of the recalcitrant components and in addition they require larger operation area and more chemical processes to reduce the sludge. The Fluidized Aerobic Bed Reactor (FAB) is an advance hybrid biological system primarily designed to reduce the usage of ground water from bore wells and to retreat the waste water for further recycling and to make effortless installation and trouble free operation while increasing the treatment efficiency. Application of biological methods such as fluidized bed reactors has generated a lot of interest in the recent past. The major advantage of fluidized bed reactor over other biodegradation systems is a higher biomass concentration, and a higher mass transfer, resulting in a higher rate of biodegradation. The application of the fluidized bed reactor makes it possible to achieve phase homogeneity and larger solid–liquid contact area. These characteristics of a fluidized bed reactor enable an operation at a high volumetric loading, a fact that makes a fluidized bed an appropriate choice for treatment of toxic effluents.

FAB is an advanced technology which is a combination of attached and suspended growth process and fluidized condition is maintained in the reactor by providing diffused aeration from the bottom of the reactor. The installed STP consists of high rate FAB reactor and tube settler forms heart of the treatment system to remove organic and suspended solids. The STPs were based on standard design criteria and engineering consideration. The cost and economic analysis indicated that capital cost, recurring cost and total cost of treatment per KLD were taken into for consideration. The civil, electro-mechanical and operation and maintenance cost contributes to 50-72%, 26-50% & 2-4% of the total treatment cost respectively. This diagnosis of groundwater resource status and strategic planning needs now requires critical review and complementary investigation to consolidate a long-term sustainable groundwater use policy.

3.1 STP CRITERIA

QUANTITY ESTIMATION OF WASTE WATER

The total ridership in the proposed North- South corridor in the year 2020 and 2041 was estimated to be 6.44 and 13.44 lakh passengers per day respectively on average basis in Lucknow. Sanitation condition may deteriorate due to inflow of large number of commuters. Current sanitation condition at the stations will be ascertained. Proper sanitation facilities to be provided and ensure the proper management of wastewater. Possible forecast Impact on ground water is expected as requirement of water for operation.

At present conditions, station cleaning works, train coaches cleaning, toilet flushing, wash room cleaning, maintenance and repair works are considered for the source of waste water. The discharge for the wastewater line by assuming rate of water supply of 75000 LPCD and out of this total supply only 75 % reaches as wastewater. Making by necessary assumption whenever necessary.

Q = 75000 L/capita/day (At one Metro station)

Waste water flow = 75% of water supply

= 0.75* 75000

= 56250 LPCD

Total Waste water generated = 56250*60000/ (24*3600)

= 39062.5 lit/sec

= 390.62 m^3 /sec.

If Comparing with total metro stations in Lucknow (i.e. Twenty-four station at presently)

The total waste water generated = 9374.8 m^3/s. (For 24 stations, As per random study).

For the proposed metro project, the utilisation of ground water also may be similar to the existing metro stations, so the quantity of fresh water succumb remains same. The removal efficiency of the FAB reactor in terms of TSS varied 83-85%, whereas for BOD 92-93% and COD 74-80% respectively. High rate of treatment efficiency within a short HRT was due to high surface area provided to the microbes, high organic loading rate and the diffused aeration provided through bottom of the STP. As compared to conventional methods FBR's efficiency is high and consistent irrespective of the climatic conditions since the system is compact and highly controlled.

Table 3.1 Achieved Parameters of wastewater from metro stations STP

S. No	Parameters	Outlet to STP (PPM)
1	PH	6.5 – 8.8
2	COD, mg/l	600-700
3	BOD, @ 20 deg. C, mg/l	300-450
4	Suspended solids, mg/l	300-350
5	Oil & grease	50

The emerging situation of ground water levels is very alarming, as such areas seems to have reached to an irreversible stage. It is well-known that, the notable ecofriendly improvement of the healing trains industry integrates the saving of energy and properties. The energy and re-sources necessary to rebuild the different components are considerably less than those required to interchange the perfect unit. An important way to upgrade this industry is to configure it according with the environment policy. An aspect of this problem is shown in this paper: solution for treat the waste water. Hence, a thoughtful management process needs to be initiated.

The prime importance in the design of a waste water treatment plant is to estimate the capacity of the STP to be designed to collect. The volume of waste water generated directly by a flow meter. Random check carried on metro stations and recorded around 75 - 80 KLD of wastewater drained out per station.

3.2 SELECTION MODE OF STP

Wastewater characteristic is assessed for suitable cost effective and economical treatment method must be chosen for setting a STP. Single point flow method is preferred as compared to conventional centralized treatment system, since it enhances waste water treatment, thereby avoiding the waste water transportation cost. The cluster installation may be enhancing to minimize the waste water transportation and maintenance cost. Most importantly modular design to optimize the organic and hydraulic loading rate of the treatment system. In addition, the prime advantage of modular design is that it can be easily added to the existing module at the time of increase in the waste water generation volume so as to achieve the maximum design efficiency in terms of organic and hydraulic loading rate.

3.3 SET UP OF STP

As per criteria and guideline values used for designing wastewater treatment facilities. Keeping the criteria, depends on the engineering conditions like topography of the area, hydraulic head, ground water depth and its seasonal variations, soil bearing capacity, type of strata expected to meet in the construction and these data are obtained from field studies. The treatment units were designed based on the standard design criteria according to the field conditions of metro stations (Based on 100 KLD per station water consumption).

3.4 WASTE WATER CHARACTERISTICS

Assessing waste water characteristic is essential for the choice of treatment method, extent of treatment, beneficial use of the wastewater and cost of treatment required. By collecting samples of raw waste water for determination of pH, TSS, TDS, BOD & COD as per standard methods (APHA, 2005). Physico-chemical characteristic of the waste water confirmed the waste water as medium strength as BOD varied from 400-550 mg/l. The pH value of 8.48 indicates alkaline nature of the waste water. Average BOD and COD 198 mg/l and 525 mg/l with BOD/COD ratio of 0.511 indicating that the waste water is biodegradable.

3.5 PERFORMANCE EVALUATION OF THE STP

Performance evaluation of the STP was carried for installed STP in the field by collecting influent and effluent samples periodically from the inlet and outlet of the constructed STP.

3.6 FLUIDISED AEROBIC BED REACTOR (FAB)

Fluidised Aerobic Bed Reactor (FAB) as the name indicates consists of floating media of cylindrical/rectangular shapes and different sizes. As compared to conventional technologies FAB reactors are compact, energy efficient and user friendly. The Fluidized Aerobic Bed Reactor (FAB) is an advance hybrid biological system primarily designed to reduce the footprint area required and to make effortless installation and trouble free operation while increasing the treatment efficiency. The Fluidized Aerobic Bed Reactor process is the latest advance in attached growth aerobic biological treatment technology. FBR employs RING PAC MEDIA, neutrally buoyant bio film carrier elements, to achieve outstanding BOD/COD removal productivity from a compact bioreactor. In Fluidized Bed Reactors, the liquid to be treated is pumped through a bed of small media at a sufficient velocity to cause fluidization. In the fluidized state the media provide a large specific surface for attached biological growth and allow biomass concentrations in the range 10-40 kg/m3 to develop. For aerobic treatment processes the reactor is aerated. This is done by recalculating the liquid from the reactor to an oxygenator where air, or possibly oxygen, is bubbled. To overcome problems related to high re-circulation rates, needed when there is high oxygen demand in the reactor, the reactor might be aerated directly. The basis for the use of fluidized bed systems is the immobilization of bacteria on solid surfaces. Many species of bacteria (and also other microorganisms) have the ability for adhering to supporting matrices. In this process, a volume of Ring Pac media is immersed in water and is fluidized (kept in constant motion) through the movement of gas and liquid in the treatment reactor. As the media supports a biomass concentration several times that achievable in activated sludge systems, treatment is significantly more productive. Fluidized Aerobic Bio-Reactor (FAB) as the name indicates consists of floating media of cylindrical shapes and different sizes. As compared to conventional technologies FBR reactors are compact, energy efficient and user friendly. Controlled air diffusion FBR based waste water treatment plant works on the principle of attached bacteria growth process supported by specially designed eco-friendly media. This type of treatment depends primarily on the use of air that is introduced into the waste water treatment plant for keeping alive the bacteria. When air diffusion is done, it promotes the growth of organisms that break down the organic solids.

3.7 BASIC PRINCIPLE OF FAB:

Flock forming organisms form clusters or attach to available surfaces. The FAB media provides a very large surface area which

- Increases the specific volumetric capacity of activated sludge tanks
- Controls biomass activity
- Reduces operating cost.

The clarified effluent enters into the FAB reactor, which contains the FAB media. The FAB media significantly increases the surface area for bacterial growth. Air is supplied through fine bubble diffusers. Bacteria oxidize the organic matter present in the waste water. Oxidized waste water overflows out of the FAB reactor, into the secondary settling tank. The Fluidised Aerobic Bio-Reactor includes a tank in any shape filled up with small carrier elements. The elements are specially developed materials of controlled density such that they can be fluidised using an aeration device. A bio-film develops on the elements, which move along with the effluent in the reactor. The movement within the reactor is generated by providing aeration with the help of diffusers placed at the bottom of the reactor. The thin bio-film on the elements enables the bacteria to act upon the bio-degradable matter in the effluent and reduce BOD/COD content in the presence of oxygen from the air that is used for fluidisation.

3.8 OPERATING PRINCIPLE OF FLUIDIZED AEROBIC BED REACTOR

The raw waste water generated from Metro stations were processed (common point) through preliminary treatments and pumped into FAB reactor (aeration tank), using submersible waste water pumps, wherein the aerobic microbes attached to the media in the reactor utilizes the biodegradable organic pollutant in presence of oxygen there by reducing BOD/ COD. The free, molecular oxygen required is provided through air grid supplied by air blower. The dead biomass along with treated wastewater flowed by gravity into tube settler tank, wherein solid-liquid separation was achieved. Tube settlers are high rate settlers of the inclined surface or shallow settling type. The settlers use inclined tubes to divide the depth into shallower sections. Thus, the depth of all particles (and therefore settling time) was significantly reduced. These clarifiers provide a large surface area reducing clarifier size. No wind effect exists, and the flow was laminar. Tubes are circular, square, hexagonal, or any other geometric shape and were installed in an inclined position within the basin. Tubes were commonly inclined steeply (55^0) to horizontal and fabricate in modules.

The solids separated were pumped to the sludge drying bed for further volume reduction. The treated supernatant dosed with sodium hypochlorite through and was allowed to react in chlorine contact/filter feed tank prior to further polishing. The treated wastewater then pumped with filter feed pump through dual media filter & activated carbon filter prior to suitable reuse like gardening and toilet flushing. The dead biomass was separated and transferred periodically into the sludge drying bed wherein mass reduction occurs. The dried sludge was further removed periodically and used as a fertilizer for plants.

3.9 PARAMETERS FOR STP AND FAB

Parameters mean the data's to be considered for analysis and calculation in case of setting the Fluidized bed reactor for the wastewater treatment. For industrial application of fluidized bed reactor, the hydrodynamics should be known. The Fluidized Bed reactor design should be made according to information available in the literature. The formulas for the design parameters are to be selected from vast literature available on researches in fluidized bed reactors and the study of fluidization profiles.FAB based modular STP to be designed based on standard design criteria listed below Table. The raw waste water generated from metro station was processed through preliminary treatment followed by biological and tertiary treatment.

The installed FAB was rectangular shaped with an average height. The reactor was filled with polypropylene carrier media occupying 30% of the total tank volume. The carrier media used offered an effective surface area ranging 200-500 m2/m3 for different shaped media. The reactors were designed for 9-12 hrs HRT and fluidized condition was maintained by providing diffused aeration at the rate of 15 m/s thereby enhancing effective oxygen transfer efficiency by allowing the waste water in full contact with the media up on which the microbes are immobilized. During fluidization operation, the carrier media expands to accommodate microbial growth. The higher the surface area for the biomass to grow higher will be the concentration of active bio-mass per unit volume of the reactor. Return sludge which is indispensable for the activated sludge process was not required enabling extremely easy maintenance control.

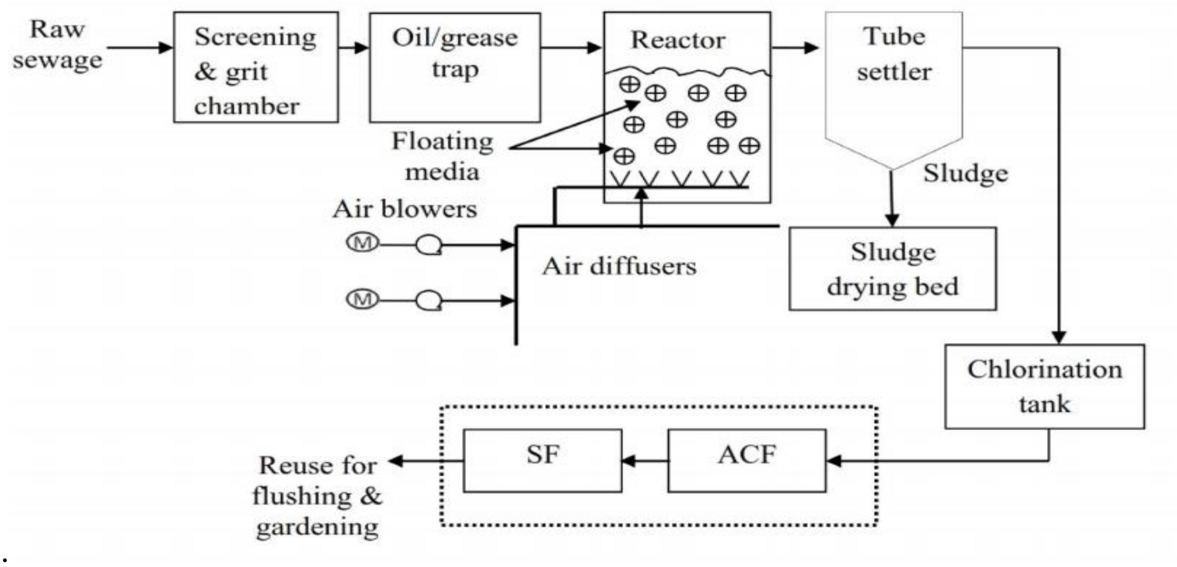

Fig. 3.1 Schematic diagram of STP based FAB

The total area required for FBR based STP including all preliminary units varied 6.40-7.46 Sq.m/KLD for 55-450 KLD, with land requirement of 0.7 Sq.m per KLD. On an average, FBR reactor alone occupies an area of 0.087 Sq.m / KLD and it varied 0.075 0.095 Sq.m /KLD. This contributes to an average of 12.6% of the total area ranging 11%-13%. The high rate tube settler occupies an area of 0.043-0.058 Sq.m /KLD which constitutes 7-8% of the total area required. This proves that FBR based STP requires 6 times lesser land than conventional treatment methods.

3.10 FAB TREATMENT STAGES (PROCESS FLOW)

First stage of treatment where physical impurities are removed. This stage includes removal of stone, food, polythene, plastic, Oil, Grease and maintaining the pH of water.

Technological Stage-1

- ✓ Bar Screen Treatment
- ✓ Oil and Grease Removal
- ✓ Equalization Treatment by maintaining the pH.

It involves Oxidation that reduces the biochemical oxygen demand of wastewater, and may reduce the toxicity of some impurities. Secondary treatment converts some impurities to carbon dioxide, water, and bio solids. Thus removing the foul odour in the waste water by increasing the amount of oxygen in the water. Removing the sludge from the waste water.

Technological Stage-2

- ✓ Aeration Treatment
- ✓ Flocculation & Coagulation through Poly electrolyte (Alum, Ferrix)
- ✓ Clarifier / Tube Settler: Settling Tank where solids called Sludge are removed from water that settles at the bottom of Tank.

This involves the disinfection of water. Disinfection by chemical oxidation kills bacteria and microbial pathogens by adding ozone, chlorine or hypochlorite to wastewater.

Technological Stage-3

- ✓ Chlorination
- ✓ Multi Grade Filtration
- ✓ Activated Carbon Filtration.

After the waste water pass through the Activated Carbon Filter, it may be collected in the Tank for further use for flushing, irrigation, gardening etc. or directed into the drain.

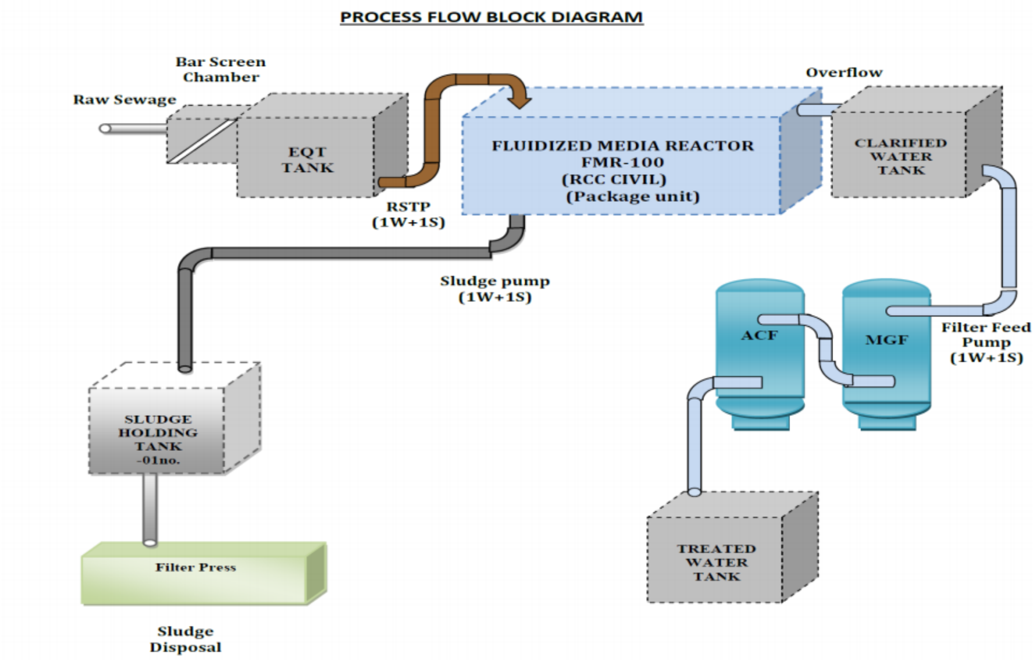

Fig. 3.2 Treatment Process flow

Table 3.2 Parameter Considerations for STP based FAB (Source: Field study)

S.NO	PARAMETER	VALUE
(A) SCREEN CHAMBER (FINE SCREEN)		
1	Velocity, m/min	2.0
2	Head Loss, m	0.8
3	HRT, min	3.0
4	Peak Factor	3.0
(B) GIRT CHAMBER		
5	Detention Time, s	60
6	Horizontal Velocity m/sec	0.3
7	Diameter of the particle removed, mm	0.15
8	Specific gravity of the particle	2.65
9	Peak Factor	3
(C) OIL & GREASE TRAP		
10	HRT, min	30
11	Peak Factor	3
(D) COLLECTION TANK		
12	Hydraulic Retention Time, Hrs	3
(E) FLUIDIZED AEROBIC BIO REACTOR		
13	Organic Leading Rate, kg BOD @ 20^0 C (Cubic meter x d)	1.0
14	Oxygen required, kg/ BOD	2.5
15	Oxygen transfer efficiency, %	12
16	Specific gravity of the element	0.9-0.93

17	Element required	30% Tank Volume
18	Specific gravity of air @ 30^0	1.165
(F) TUBE SETTLER		
19	Surface leading Rate	20
20	Tube inclination degree	55
21	Tube shape	Rectangular/Cylindrical
(G) SLUDGE DRYING BED		
22	Area of sludge drying bed, Sq.m/Capita	0.03
23	Sludge removal cycle, days	10
24	Depth of sludge provided, m	0.3
25	Depth of sand layer	0.15
26	Depth of gravel layer	0.2
27	Drain pipe diameter, mm	200

CHAPTER 4

RESULTS AND RECOMMENDATIONS

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Environmental Consultants and Analytical Laboratory

(An ISO 9001:2008 Certified Company)

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Contact No. : 9711159210, 9711159427 E-mail : email@ekopro.in, ekoproengineers@gmail.com, website : www.ekopro.in

For Any Query Contact
Group: A-7458913093

TEST REPORT

Waste Water Analysis

Test Report No.: EKO/EV-WW/1602/16/2018 Issue Date 28/03/2018

Issued To	Velmurugan No-16 Station Road Lucknow
Sample Description	Waste Water (Sediment Tank Outlet)
Sample Drawn on	15/06/2018
Sample Drawn by	EPEPL (Mr. Arvindakshan)
Sample Received on	26/03/2018
Sampling Location	From Charbagh Stn
Sampling Plan & Procedure	SOP-W/06
Sample Quantity	4.0 Litre
Environmental Condition	Normal
Analysis Duration	27/03/2018 To 28/03/2018
Remark (if any)	NA

RESULTS

S.No.	PARAMETER	Test Methods	Result	Units
1	pH	IS : 3025 (P-11)	8.19	-
2	Total Dissolved Solids	IS : 3025 (P-16)	1048.0	mg/L
3	Total Suspended Solids	IS : 3025 (P-17)	350.0	mg/L
4	COD (as O2)	IS : 3025 (P-58)	700.0	mg/L
5	Oil & Grease	IS : 3025 (P-39)	50	mg/L
6	BOD (@27°C for 3 days)	IS : 3025 (P-44)	450.0	mg/L

End of Report

Notes:

1. The results given above are related to the tested sample, as received & mentioned parameters. The customer asked for the above tests only.
2. This test report will not be generated again, either wholly or in part, without written permission of the Laboratory.
3. This test report will not be used for any publicity/legal purpose.
4. The test samples will be disposed off after two weeks from the date of issue of test report, unless until specified by the customer. Sample received for biological tests will be destroyed after 7 days from the date of issue of test report.
5. Responsibility of the Laboratory is limited to the invoiced amount only.

For EKO PRO ENGINEERS PVT. LTD.

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Page No. 1/1

Fig 4.1 Waste water test report taken from field study on Sediment Tank from Metro Stations

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For Any Query Contact
Group : A-9711159337

TEST REPORT

Waste Water Analysis

Test Report No. : EKO/EV-WW/102/160318 Issue Date 20/04/2019

Issued To	Velmurugan No-18 Station Road Lucknow
Sample Description	Waste Water (Sedimantation Tank Outlet)
Sample Drawn on	15/04/2019
Sample Drawn by	EPEPL (Mr. Arvindakshan)
Sample Received on	15/04/2019
Sampling Location	From Charbagh Site
Sampling Plan & Procedure	SOP-W/66
Sample Quantity	2.0 Litre
Environmental Condition	Normal
Analysis Duration	16/04/2019 To 20/04/2019
Remark (If any)	NA

RESULTS

S.No.	PARAMETER	Test Methods	Result	Units
1	pH	IS : 3025 (P-11)	8.19	-
2	Total Dissolved Solids	IS : 3025 (P-16)	1052.0	mg/L
3	Total Suspended Solids	IS : 3025 (P-17)	74.0	mg/L
4	COD (as O2)	IS : 3025 (P-58)	194.2	mg/L
5	Oil & Grease	IS : 3025 (P-39)	< 4.0	mg/L
6	BOD (@27°C for 3 days)	IS : 3025 (P-44)	27.0	mg/L

"End of Report"

Notes :

1. The results given above are ralated to the tested sample, as received & mentioned parameters. The customer asked for the above tests only.
2. This test report will not be generated again, either wholly or in part, without written permission of the Laboratory.
3. This test report will not be use for any publicity/legal purpose.
4. This test samples will be disposed off after two weeks from the date of issue of test report, unless until specified by the customer. Sample received for biological tests will be destroyed after 7 days from the date of issue of test report.
5. Responsibility of the Laboratory is limited to the invoiced amount only.

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Fig 4.2 Waste water test report taken from field study after FBR process

COMPARATIVE RESULTS

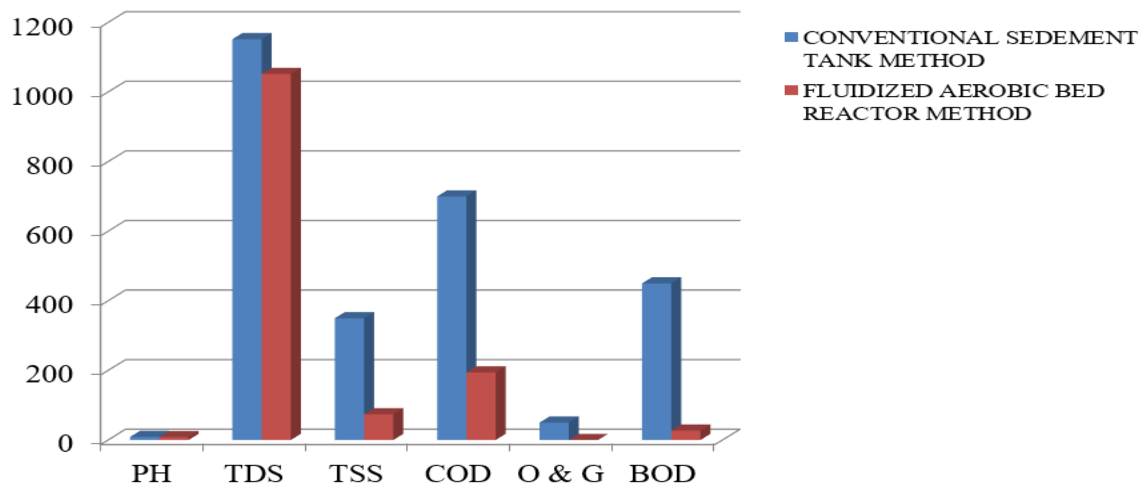
Table 4.1 **Before: In Conventional Methods (Sediment Tank)**

S.NO	PARAMETERS	TESTMETHOD	RESULTS	UNITS
1	PH	IS:3025(P-11)	8.8	-
2	Total Dissolved solids (TDS)	IS:3025(P-16)	1648	mg/L
3	Total Suspended Solids (TSS)	IS:3025(P-17)	350	mg/L
4	COD(%O2)	IS:3025(P-58)	700	mg/L
5	Oil and Grease	IS:3025(P-39)	50	mg/L
6	BOD(@27c for 3 days)	IS:3025(P-44)	450	mg/L

Table 4.2 **After: Fluidized Aerobic Bed Reactor Method**

S.NO	PARAMETERS	TESTMETHOD	RESULTS	UNITS
1	PH	IS:3025(P-11)	8.19	-
2	Total Dissolved solids	IS:3025(P-16)	1052.0	mg/L
3	Total Suspended Solids	IS:3025(P-17)	74.0	mg/L
4	COD(%O2)	IS:3025(P-58)	194.2	mg/L
5	Oil and Grease	IS:3025(P-39)	<4.0	mg/L
6	BOD(@27c for 3 days)	IS:3025(P-44)	27.0	mg/L

Fig 4.3. ANALYSIS OF WASTE WATER SEDMENTATION



4.1 COST ESTIMATION TO SET FAB FOR METRO STATIONS.

The best systems among the wastewater treatment systems that meet standard may be selected on the basis of minimum cost, including construction, capital, maintenance and operating and cost associated with plant maintenance cost over a designated planning horizon. The estimation of FAB treatment plant cost is based on the size, type and quantity of plant needed to set the FAB reactor The cost of FAB plant is estimated by multiplying the quantity of equipment by its current price and summing. The cost of equipment is a major part of the total capital cost for a water treatment system. In addition, some of the equipment can be rented or leased. This category also includes Oil, Grease trap and Girt Removal system, Air Blower, Aeration Tank, FBR Media, Tube settler tank, Manual/PLC Based Electrical control panel, Filter feed pump and miscellaneous items. Plant operation cost is the variable part of the cost of the treatment plant. It comprises of chemical cost, energy cost, staff, maintenance, monitoring and labor cost. It is cost incurred in running of day-to-day activities. Labor cost can be calculated based on the number of hour per work. It will be estimated base on the current wage of the labor per hour. In estimating operation cost, there are general assumptions, which should be considered:

a) The number of operation hours in a year is 365 hours
b) The unit cost of electricity use during the operations. This has significant effects on the cost of operations.
c) The capacity of the treatment plant.
d) The unit cost of materials to be added during plant operation.
e) Chemical costs are for those chemicals used in the wastewater treatment plant. However, this cost estimating depends on the quantity of the chemical use during treatment process and the price of the chemical per Kg.
f) The annual economic cost of treatment systems to be expressed as the total annual capital cost and combination with operating cost of treated water produced.

For a long term process the FAB technology will definitely help to sustain in wastewater treatment and more efficiency in the process.

Table 4.3 Cost estimation for Fluidized Aerobic bed reactor set up

S.N	Descriptions	Quantity/Size
	Capacity	**For 50 KLD Unit**
1	Tank shall be MSFRP(Mild steel Fiber Reinforced Polymer/plastic) and corrosive.	01 set.
2	**STP with FBR Unit**	
A).Primary Treatment		
3	Manual bar screen.	01 set.
4	Oil, Grease trap and Girt Removal system.	01 set.
B).Secondary Treatment		
5	Raw waste water transfer feed pump.	01 set.
6	Air Blower.	01 set.
7	Agitator for Anoxic Tank.	Each.
8	Aeration Tank.	01 set.
9	FBR Media for FBR Tank.	01 set.
10	Diffuser System.	01 set.
11	Tube settler tank.	01 set.
12	Chlorine dosage system in clear water Tank.	01 set.
13	Plant/Interconnecting Piping and valves.	01 set.
14	Manual/PLC Based Electrical control panel.	01 set.
15	Incoming/Outgoing feeder.	01 set.
16	Cable laying with cable tray.	01 set.
17	Earthing system.	01 set.
18	Pressure gauges.	01 set.
19	Level switches.	01 set.
20	Online rotameter.	01 set.
21	Air rotameter.	01 set.
21	Flow meter.	01 set.
22	Filter feed pump.	01 set.

Continued

23	Multi grade sand filter.	01 set.
24	Activated carbon filter.	01 set.
C. Sludge Handling system		
25	Sludge recycling Pump.	01 set.
26	Sludge feed screw pump.	01 set.
27	Filter press system.	01 set.
28	Sludge holding tank.	01 set.
29	FRP.	3MM.
30	BIO Media Surface Area.	700M3.
31	BIO Media.	1 CUM.
32	Air Blower.	1 HP.
33	Sodium Hypochlorite (During Treatment).	As required.
34	Chlorine(During Treatment).	As required.
35	Carbon Filters (During Treatment).	As required.
Amount (Approx.)		**INR 16,61,445.00/-**
Amount (Approx.) (For 100 KLD set up.		**INR 28,75,171.00/-**


Fig. 4.4 Sample of 50 KLD FAB set up.

4.2 ADVANTAGES OF FLUIDIZED AEROBIC BIOREACTOR

A. Significant reduction in space requirement due to high surface area & loading rate of FMR media
B. Reduced power and operating costs.
C. No Sludge recycle
D. No moving parts, less maintenance.
E. Minimum Land usage.
F. Minimum Power and Chemical Requirement
G. Operate plants in low temperature areas
H. Self- Regulating System and Odourless Operation.
I. Less maintenance and better oxygen transfer efficiency due to non-clogging design and fluidized bed principle.
J. High resident biomass concentration, intense mass transfer conditions and aggressive biomass-sloughing action enable the process to rapidly respond to variations in process load.
K. Uniform liquid flow distribution.
L. Small installation is required.
M. To protect the Environment and states water resources.
N. To promote Recycle, Reclaim and Reuse of Treated waste water for Non-potable drinking purposes.
O. Increase in the adequate waste water coverage to all.
P. Reuse of Treated waste water can provide incremental supply for Non-potable applications and thus reduce need for augmenting supplies.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The thesis showed that the main source of the raw wastewater flowing out from metro stations is discharging the wastewater with large quantities up to 75% out of fresh water per day, which is considered as a real threat to all walks of life in Lucknow metro city stretch catchment. However, it is less susceptible to the adverse effects of the discharged raw wastewater due to its applications itself. An important negative result of the flow of the wastewater thorough the region is distortion of the aesthetic view of the local nature, which was a recreation area where people were spending their time on the banks of the Gomti river enjoying the beauty of nature before discharging a huge amounts of raw wastewater into the public drains and increasing the wastewater proportion against fresh water within the flow. On the other hand, the dry season suffered from delayed and minimum rainfall and a contrary effects of the ground water level decreasing rapidly.

Unexpectedly, some physical parameters such as pH were increasing whenever wastewater were going toward the end point station. This can be explained by the serious contribution of wastewater discharging from metro stations may increase in alkaline pollutants. By considering the advantages of Fluidized aerobic bed reactor, it suits in the modern methods of wastewater treatment in Metro rail stations of Lucknow. It can maintain a high effective concentration of microorganisms and provides stability against shock and toxic load. Today, the load of pollutants in natural water bodies has increased manifold. There are possible solutions to the problem. The existing works can either be extended with implementing the FAB methodology to treat the wastewater, so that the fresh water is reduced. There are, therefore, considerable savings to be made if some form of add on advanced plant can be established. Fluidized aerobic bed reactor have this potential. Thesis is carried out to minimize the potential of ground water source and public water utilities used on daily basis for metro stations and recommending to FAB (Fluidized aerobic bed reactor) implementation in metro stations to minimize the fresh water and to recycle and reuse. Also efforts should be made to standardize the procedure of wastewater treatment on Metro rail locations. For waste water treatment at by using FAB technology delivers treated water to meet the local discharge norms and can be used as a decentralised compact waste water treatment plant system for metro's. The invention of this technology made it possible to significantly decrease the fresh water at Metro rail stations and allow for a cleaner, more efficient process instead of draining on to public utilities.

5.2 RECOMMENDATIONS

Building on the main findings of this research which were extracted directly from the observations, the following key recommendations are proposed within namely outlined interventions according to some gaps that must be studied and some steps that could reduce the risk of the hazardous raw wastewater:

The reasons of this choice were the complexity of this activity and also, the possibility to evaluate the experimental implementation of the project.

- Building up a proper wastewater treatment plant in order to mitigate the catastrophic effects of the wastewater in the Lucknow metro stretch, as a result, this can help in applying the sustainable development concept and converting these negative effects of the wastewater into water reuse and other purposes.
- The competent authorities should do the necessary measures to reduce the fresh water utilization, indeed, it to treat the wastewater within the metro stations instead of relying on ground water and public water utilities.
- The Multi-source pollution issue that affect groundwater must be taken into account in the future studies in the study area.
- Further similar researches are required in order to study the wastewater flow of other metro rail cities to control the overburden of wastewater.

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2	Enrollment No: 1170470011				
3	Thesis title: Waste Water Treatment in Metro Rail Stations by Fluidized Aerobic Bed Reactor				
4	Degree for which the thesis is submitted: Master of Technology (Environment Engineering)				
5	Faculty of the university to which the thesis is submitted: Kamalnabh Tripathi				
6	Thesis Preparation Guide was referred to for preparing the thesis.	[ ]	Yes	[ ]	No
7	Specification regarding thesis format have been closely followed	[ ]	Yes	[ ]	No
8	The contents of thesis have been organized based on the guideline	[ ]	Yes	[ ]	No
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11	The thesis has not been submitted elsewhere for a degree	[ ]	Yes	[ ]	No
12	All the corrections have been incorporated.	[ ]	Yes	[ ]	No
13	Submitted 3 hard bound copies plus one CD	[ ]	Yes	[ ]	No

(Signature of Supervisor)

Name: Kamalnabh Tripathi

(Signature of the Candidate)

Name: Velmurugan. P

Roll No:1170470011

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1 Name: Velmurugan.P.

2 Enrollment No: 1170470011

3 Thesis title: Waste Water Treatment in Metro Rail Stations by Fluidized Aerobic Bed Reactor

4 Degree for which the thesis is submitted: Master of Technology (Environment Engineering)

5 Faculty of the university to which the thesis is submitted: Kamalnabh Tripathi

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(Signature of the Candidate)

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Urkund Analysis Result

Analysed Document: FAB_ Final Thesis_23_07_19_Vel (1).doc (D60698805)
Submitted: 12/10/2019 12:03:00 PM
Submitted By: kamalnt11@bbdu.ac.in
Significance: 16 %

Sources included in the report:

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https://www.researchgate.net/publication/265340542_Basic_Design_of_a_Fluidized_Bed_Reactor_for_Wastewater_Treatment_Using_Fenton_Oxidation
https://www.ijert.org/waste-water-treatment-in-underground-metro-rail-stations-by-using-fluidized-aerobic-bio-reactor
https://greenecowater.com/sewagewater-treatment-faq.html
https://www.irjet.net/archives/V6/i3/IRJET-V6I3472.pdf
https://vdocuments.mx/eia-for-dwarka-to-iffco-chowk.html
https://vdocuments.mx/study-of-widely-used-treatment-technologies-for-hospital-wastewater-and-their.html
https://www.adb.org/sites/default/files/project-document/63918/38254-04-ind-iee-07.pdf
https://www.science.gov/topicpages/w/wastewater+treatment+bioreactors
https://zeanlitho.com/2019/06/03/sewage-treatment-plant-stp-effluent-treatment-plant-etp/

Instances where selected sources appear:

62

REFERENCES

1. Aoyi Ochieng, Tom Ogada, William Sisenda, Paul Wambua, Brewery., 2000. *Wastewater treatment in a fluidized bed bioreactor*, J. Hazard. Mater, 2000:90:311–21.

2. Aoyi Ochieng, John O. Odiyo, Mukayi Mutsago., 2003. *Biological treatment of mixed industrial wastewaters in a fluidized bed reactor*, J. Hazard. Mater, 2003:96: 79–90.

3. *Biofilm Reactors* - WEF MOP 35, Section 5, Moving-Bed Biofilm Reactors, Table 5.1. Plastic biofilm carriers, Table 5.3. Typical BOD design loading criteria

4. B.Piere, R. Molette., 1999. *Some hydrodynamic characteristics of inverse three phase fluidized bed reactor,* Chem. Eng. Science, 1999:54: 1233-42.

5. P.Castilla, M.Meraz, O.Monroy, A.Loyola., 2000. *Anaerobic treatment of low concentration wastewater in an inverse fluidized bed reactor*, Water Sci. Technol, 2000:41: 245–51.

6. D.Garcia-Bernet, P.Buffie`rre, S.Elmaleh, R.Moletta., 1998. *Application of the down-flow fluidized bed to the anaerobic treatment of wine distillery wastewater*. Water Sci. Technol, 1998:38: 393–9.

7. *Design of Municipal Wastewater Treatment Plants:* WEF Manual of Practice No. 8 - ASCE Manuals and Reports on Engineering Practice No. 76, Fifth Edition, Section 13.3, Moving Bed Biofilm Reactors, Table 13.3, Plastic Biofilm Carrier Characteristics, Equation 14.34

8. *Handbook of Environmental Engineering Calculations,* Second Edition, Example 1.A, steps 13 – 16 Nalco Water Handbook, Fourth Edition, Chapter 23, Equation 6 Standard Handbook of Environmental Engineering, Second Edition, Sec 6.5.1. Activated Sludge.

9. K .Haribabu, V.Sivasubramanian., 2013. *Determination of Mass Transfer Coefficient in an Inverse Fluidized Bed Reactor using Statistical and Dynamic Method for a Non-Newtonian Fluid*, J. scient. Indus. research, 2013:72: 485-90.

10. L.S. Fan, W.T.Tang., 1990. *Gas–liquid mass transfer in a three phase fluidized bed containing low density particles*, Ind. Eng. Chem. Res. 1990:29: 128–33.

11. M. Rajasimman, C. Karthikeyan., 2007. *Aerobic digestion of starch wastewater in fluidized bed bioreactor with low density biomass support*, J. Hazard.Matter 2007:143:82-6.

12. Sowmeyan, G.Swaminathan., 2008. *Evaluation of inverse anaerobic fluidized bed reactor for treating high strength organic waste water*, Biores. Tech, 2008:99:3877-80.

13. V. Nikolov, I. Farag., 2000. *Gas–liquid mass transfer in bioreactor with three-phase inverse fluidized bed*, Bioprocess. Eng, 2000:23: 427–9.

14. V Sivasubramanian., 2010. *Gas-liquid mass transfer in three-phase inverse fluidized bed reactor with Newtonian and non-Newtonian fluids*, Asia-Pacific J Chem Eng, 2010:5:361-8.

15. W.Sokol, M.R.Halfani., 1999. *Hydrodynamics of a gas, liquid, solid fluidized bed bioreactor with a low density biomass support*, Biochemical Eng. J, 1999:3:185-92.

16. W.Sokol, A. Ambaw, B.Woldeyes., 2009. *Biological wastewater treatment in the inverse fluidized bed reactor,* Chem. Eng. J, 2009:150:63-8.

17. W.Sokol, B.Woldeyes., 2011. *Evaluation of the Inverse Fluidized bed reactor for treating high strength Industrial Wastewaters,* Advance. Chem. Eng. Sci, 2011:1:239-44.