RESEARCH ARTICLE OPEN ACCESS

Zero Discharge Concepts in Five Star Hotel – A Case Study

A.Mubarak[1,] A. Huma[1,] F. Ahmad[1,] K. Ahmad[2,]Inamul - Haq[3]
[1]*B.Tech, Department of Civil Engineering, JamiaMilliaIslamia, New Delhi, India*
[2]*Professor, Department of Civil Engineering, JamiaMilliaIslamia, New Delhi, India*
[3] *UGCScholar-in-Residence, Department of Civil Engineering, JamiaMilliaIslamia, New Delhi, Ind*ia
Corresponding Auther: A.Mubarak

ABSTRACT
Concept of zero liquid discharge (ZLD) not only offers a solution to protect water bodies from pollution by the disposal of large quantity of industrial and municipal wastewater but also provides a sustainable approach for conservation of water resources by the process of reuse and recycle of wastewater. Industry & commercial establishment should realised that adopting this concept, as the resources getting limited and its cost being increased, leads to (i) tangible economic benefits and (ii) safeguard the environment quality lest apply pollution pays principles on polluters due to the environmental damage. Hence ZLD C is must to be followed. The present paper aims at to assess the zero liquid discharge in a large commercial complex – Hotel Andaz ,Aerocity, New Delhi. The study includes assessment of water consumption, wastewater generation from different sections such as kitchen, laundry, and toilets etc. and their treatment with the application of different waste treatment systems. Base on quality of treated wastewater, reused and water balance was prepared .The treated WW (at pre-stage after chlorination followed by dual media filter and activated carbon (AC) filter) showed water quality parameters as BOD , COD , and TSS at 5.0, 10.0 and 5.0 mg/l respectively. The oil & grease was negligible and pH = 6.5 to 8.5. The treated water at this stage found to be suitable for re-use in secondary purposes mainly in horticulture, flushing of toilets or floor cleaning. However, the treated water at this stage contain hardness so water was further treated at stage -2 to improve its quality which is quite suitable for reuse as boiler feed, cooling water system, and fire fighting demand. The findings suggest that by proper adoption and strict monitoring and implantation of wastewater treatment systems at various stages the zero liquid discharge is successfully achieved.
Keywords: Zero Liquid discharge,commercial complexes (Hotel), water conservation, wastewater Treatment2-

---

Date of Submission: 20-06-2018 Date of acceptance: 09-07-2018

I. INTRODUCTION

The commercial complex such as 5-start hotels, malls, etc. are utilizinghuge quality of water resources for its day-to-day activities and also generates large quantities of wastewater. The wastewater generated is either disposed off directly in many cases without treatment or with partial treatment to sewer or drains joining river. Water and wastewater are considered as an important resource which is becoming limited and wasting it mean loss of money, resource, and degradation of environmental quality which poses an economic burden as remediation cost. Zero liquid discharge (ZLD) is, therefore, an important concept to conserve water resource and control water and land pollution. This concept aims at treating the wastewater generated in such a way that the treated water so obtained finds usage in various secondary purposes as well as various processes of the commercial & manufacturing establishments and thus, theoretically speaking, no water is left to be discharged in water bodiesindicatingzero percentage of water wasted means the fullest utilization achieved.

This concept is being implemented by the Environmental regulatory agencies initially targeting highly water polluting industries such as pulp& paper, distilleries, sugar, textile and tanneries and insist them to control pollution of river Ganga, a largest river in India . However, this idea is equally useful from economics and water conservation point of view from all sectors in view of the Water Cess Act 1977 (The Gazette of India 7th Dec. 1977) and amended **in** 2003 as notified by ministry of Environment, Govt. of India (source: Notification, 6 th May , 2003 , ministry of Environment & Forest). Under the said Act Water Cess Rule 1978 which defines rate of Cess on the basis of Water Consumption and cess rebate / incentive for better waste treatment performance. The Environmental regulatory agencies under the Act which is an economic tool to control pollution conserve resources brought out the zero liquid discharge (ZLD) concept for the industries and other establishment which provides a sustainable approach for reuse and recycle of wastewater which

are produced in a large quantity in commercial area.

The Central pollution control Board has issued direction under Section 18(1)(b) of Water Act 1974 as amended in 1988 to Pollution Control Board of five Ganga Basin states to direct industries to adopt measures and achieve Zero Liquid Discharge (ZLD) standards. Many Such industries have achieved ZLD and others have submitted action plan for implementation of Charter.

Previously a lot of developments have been made in the context of the ZLD concept. Rao (1995) stated that in thedisposal of wastewater, a high concentration of detergents released in water bodies. The Health Regulatory Authorities have set very stringent limit for detergents at 0.5mg/l for drinking water and 1.0 mg/l for various other household purposes and therefore the idea of utilization of wastewater after proper treatment is needed to protect the recipient system. Thedyeing industries use large quantity of chemicals and effluents from such units cause ecological disturbances due to release of toxic dyes and colour.G.Vishnu (2008) et al reported that one of the dyeing and bleaching unit inNorth-East state produces about 5000-7000 m3/d of effluent with chloride conc. and total dissolved solid (TDS) ranging between 2000-3500 mg/l (tolerable limit, 1000 mg/l) and 5000-7000 mg/l (tolerance limit,2100 mg/l for TDS). On recognising the seriousness of the problem, the industry had been insisted by the pollution control Board (PCB) to adopt suitable treatment plant to achieve no disposal of wastewater by using the Zero Discharge Concept as a means to recycle and reuse the treated water and salt [2].The wide varieties of chemicals &wastes discharged through wastewater which caused adverse impacts motivated the researchers to adopt a suitable treatment system based on membrane, ion exchange and biological technologies[3](P.A.Shivajirao(2012). The capital required to implement new technologies ,and their economic evaluation in terms of benefits of treatment to get the full reuse of wastewater are important consideration to implement the zero effluent discharge [4](Panaitescu M. et al ,2015). The concept to recovering the waste water after proper treatment has been implemented in various industries. It is actually being practised round the globe. Zero Liquid Discharge has become the basic norm for the treatment of the wastewater from the Coal Power Plant, the Flue Gas Desulphurisation (FGD) and, the cooling towers. One of the largest coal fired power plant (CFPP) in China implemented the ZLD concept for the boiler makeup water. The technology used to treat 630 litres /d water of CFPP and reused it and thus reducing the intake of local surface water (World 1St ZLD) [5]..Semiconductor industry set-up a plant and claimed that the plant remove 99% of waste from wastewater generated and reducedconsumption of water in the process to the extent at about 85% of total water used in the industry (F.Tillberg, 2004) [6]. The major approach was the use of coagulants to maintain pH followed by low pressure filtration and correspondingly de-water the solid waste. The electroplating unit wastewater treatment system mainly for Ni and Cr for achieving the ZLD adopted treatment systems based on filtration such as ultra-filtration (UF), carbon filter adsorbing toxic metals and other impurities. The pre-treated water subjected to ion exchange resin producing pure demineralized water which is quite suitable for re-use in the plating process.Crystallization and spray concentrators produce mixed salts from solid waste which can be be used[6]. M. Chimeng (2014) stated that the large quantity of wastewater from cooling systems is recovered using Cooling Tower Blowdown(CTBD)treatment system which uses ultrafiltration and Reverse Osmosis (RO) techniques. The system also includes unit for the reduction of hardness and silica. The ZLD system designed to recover> 85 % use-able water from the total generation of wastewater at180 m3/d. The treated water is fully utilized in cooling systems[7].Some rejects & evaporation losses were also shown. J. Wang et al (2014) reported that the effluent from the palm oil industries generates large quantity of concentrated acidic effluent characterised with bad odour, high COD, and BOD, suspended solid, oil & grease. The plant adopted a treatment system to achieve the treated water as per the standards stipulated by the American boiler manufacturers association. The treated water is completely reuse as boiler feed water and thus achieving the zero liquid discharge. The solid waste generated is used as conventional fertilisers.[8]A study was carried out in a Pharmaceutical manufacturing plant (SG et al 2015) and wastewater generated were categories in two streams based on their characteristics for treatment using different techniques to achieve zero discharge. The streams include – (i) High Concentration streams: (COD>15000mg/l and TDS>8000mg/l), and (ii) LCS or Low Concentration streams: (COD<15000mg/l and TDS< 8000mg/l).S. Gangavarapu et al(2015).The two streams (the wastewater) treatment systems consists of (a) for HCS unit, a solvent stripper, Multiple effective evaporator and Agitated Thin Film Drier (ATFD), and (b) for LCS unit-a waste water equalization system, biological system-asequential batch reactor(SBR) and membrane bioreactor (MBR). The plant also has effluent

recycling unit (ERU). The water obtained after wastewater streams treatment is recycled by the ERU using RO. The finally treated water resulted reduction in the parameter such COD and TDS at 99.9% .whereas BOD and TSS removal were 100% [9]

Present study was undertaken to assess the treatment schemes adopted for STP and ETP to achieve the zero liquid discharge concept in a large capacity hotel establishment - a commercial complexin Delhi

Description of 5- Star Hotel and its adjoining areas

5-Star Hotel M/S Andazlocated at Aerocity near IGI airport, in south-west region of New Delhi, was selected as the commercial complex to study the working of Sewage Treatment Plant (STP) and Effluent Treatment Plant (ETP) and how these treatment plants were contributing towards the idea of Zero Liquid Discharge. The hotel surveyed has total plot area of about 26800 m^2 in which unpaved area is found to be about 9000 m^2. The number of workers employed currently accounts up to 1000-1200. The area occupied by the terrace is about 8000 m2 and adopted the rain water harvesting scheme

According to the Central Ground Water Board (CGWB), the water table of the South West region where the hotel facility and other number of large establishments located, dropped by 5m-7m. There has been a huge depletion in the ground water level due to excessive exploitation and very little recharge. Water table in the area could be about 70m-80m deep. Ever increasing population and rapid urbanization have put a lot of pressure on the existing water resources.

Not only does it become necessary to improve the water quality as per the norms but also it is inevitable to recycle the water and further, if possible, contribute towards recharging the ground water. The Sewage Treatment Plants in the commercial complexes are planned to meet these requirements to a greater extent. Due to the lack of water resources and strict enforcement by the PCB and also in their own interest, the commercial complexes are contributing towards Zero Discharge Concept with the help of well-designed treatment systems.

Survey &Technique adopted for wastewater management to achieve ZLD

Present assessment involves the processes that are being undertaken in the hotels and restaurants for waste discharge from different sections like sewage, laundry, and kitchen etc. and their treatmentsto achieve the fullest possible extent to utilize the treated water for different purposes without any wastage. .

The hotel employed many environmental benefitting techniques like rain-water harvesting system and solid waste management system. The Hotel set-up an efficient sewage treatment plant as well as an effluent treatment plant to achieve zero effluent discharge

The kitchen wastewater after removal of large amount of oil and grease was treated along with the sewage treatment plant.Water discharged from laundry is treated in a separate unit as it contains high amount of COD. The water after chlorination through chlorine contact tank and filtration is used for horticulture, gardening, irrigation and floor-cleaning. For process and other use in the hotel, the water is subjected to tertiary treatment by employing the following techniques:

- Multi-grade pressure filter,
- Activated carbon filter,
- Softeners,
- Ultra filtration,

The treated wastewaterafter these steps i.e, referred as stage -1 treatment is used in flushing system.However , the treated water is not fit for further use , it is further subjected for treatment through large softeners, filters & RO. The water referred as stage 2 treated one is sent to cooling towers and in boilers or other machineries which are susceptible to corrosion and severely damaged eventually if there is any hardness left in the water.

Wastewater Treatment Technique:

The wastewater is collected and passes through a bar screen where larger size waste materials present is segregated. The wastewater then allowed entering through oil and grease chamber where 90% to 95% oil & grease is removed present mainly from kitchen section , and a sub-unit in oil &grease chamber have cutter pumps which further removes the extra oil & grease. Waste water from this unit passes in equalisation tank where wastewater from laundry unit having high COD mixed and reaches the aeration tank for biological treatment carried out by MBBR (Moving Bio Bed Reactor) system. After certain HRT the wastewater enter into clarified from where the sludge is removed through tube settlers and taken to sludge holding tank. The clarified effluent showed about 90-85% of the BOD and COD are removal after the MBBR. The water at this stage after chlorination via dual media filters and activated carbon (AC) filter is used for horticulture. However, the treated water at this stage cannot be used for cooling towers or boiler feed as the water contain high hardness, and therefore sent to softeners to remove hardness**.** Ultra filtered water is used in flush. The UV system

is used to kill bacteria at 99 %. Sludge is dewatered by filter press to squeeze out water. Logic control panels are used in filtration where electrically operated valves are used. A conceptual layout of the treatment scheme for wastewater treatment to implement the zero liquid discharge ideas is shown in chart below.

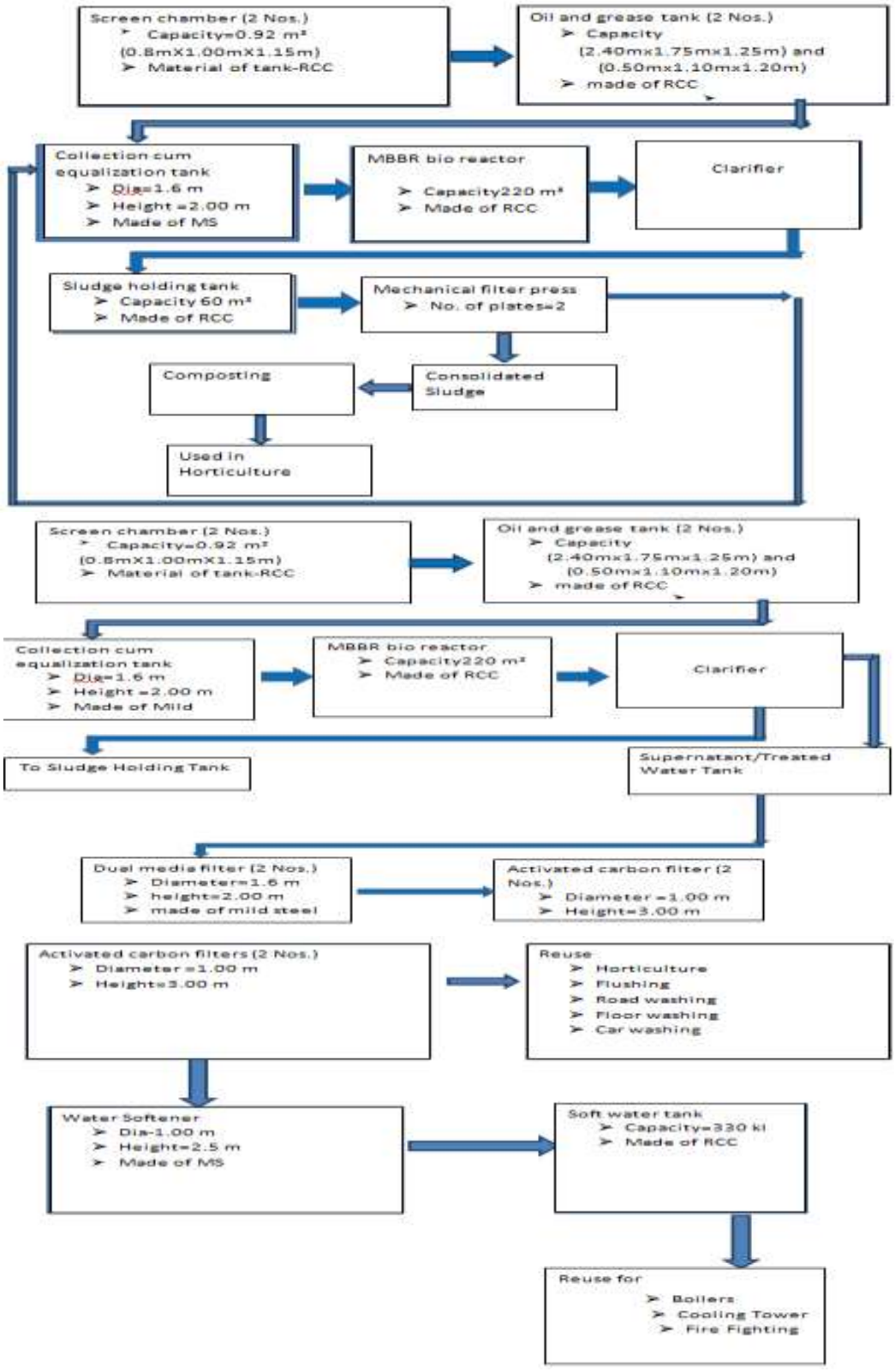

Fig. 1 Conceptual Wastewater Treatment Scheme

II. RESULTS& DISCUSSIONS:

The Sewage Treatment Plant is installed for a design capacity of 550KLD of wastewater. The plant can treat the WWhaving BOD, COD, Oil & grease and TSS up to 330mg/l, 600 mg/l, 40 mg/l and 200mg/l as the design parameter. The water obtained after ultra-filtration in the STP has the characteristics such as:BOD, COD, and TSS at 5.O mg/l,10.0 mg/l, and 5.0 mg/l. Oil & grease is negligible and pH=6.5 to 8.5.This water is suitable to be used for horticulture, flushing, car wash, floor cleaning, etc. However, this water cannot be used for fire demand, cooling tower, and boilers feed as water contain hardness (Figure 1), after passing through softeners and RO stage-2, the water is found quite suitable for use in cooling towers, boilers and for fulfilling fire demand. The water after stage-2 has the following characteristics:- BOD=0.0 mg/l; COD=0.0 mg/l; TSS=0-1 mg/l; oil & grease=0.0 mg/l. (Table 1)

Table 1: Treated water quality and use pattern

Parameter	wastewater before treatment mg/l	treated WQ after filters & AC,	After Ro-stage-2
BOD	300	5	0
COD	600	10	0
TSS	200	5	0-1
O/g	40	negligible	0

Table 2: Water Consumption Pattern

S. No.	Description	Total Number of Units	Total Population	Total Water Demand Per Person Per Day	Total Water Requirement	Domestic Cold Water Demand	Recycled Water Demand	Domestic Hot Water Demand	Flow to Sewer (80%)
1	Guest Room @ 2.0 person per room	530	1060	250	@250 ltspcpd	@115 ltspcpd	@60 ltspcpd	@75 ltspcpd	@80%
					265000	121900	63600	79500	212000
2	Hotel Staff Permanent	530	110	135	@135 ltspcpd	@ 55 ltspcpd	@45 ltspcpd	@ 35 ltspcpd	@ 80%
					14850	6050	4950	3850	11880
3	Hotel Day Staff	530	110	45	@45 ltspcpd	@20 ltspcpd	@20 ltspcpd	@ 5 ltspcpd	@ 80%
					4950	2200	2200	550	3960
4	Visitors	530	530	15	@15 ltspcpd	@5 ltspcpd	@5 ltspcpd	@5 ltspcpd	@80%
					7950	2650	2650	2650	6360
5	For Kitchen (1060x3 + 220x2 + 1500x1) = 5120 meals @ 12 lt per meal		5120	12	12 lt per meal	@8 lts per meal		@4 lts per meal	@80%
					61440	40960		20480	49152
6	R.O P0lant For Drinking Water For Guest Room and Preparation of Food and Beverages	1060x1.5 Litres (for guest)+ 5120 mealsX3 = 16950lts say 17000 LPD			Assuming Yield of R.O Plant @50%				@ 50%
					34000	34000			17000
7	Banquet Hall	Total area= 3484 sq.meter (including Ballroom and Studios)	5360 persons @0.65 sq.m per person	15	@15 ltspcpd	@5 ltspcpd	@5 ltspcpd	@5 ltspcpd	@80%
					80400	26800	26800	26800	64320
8	Water for laundary @ 8kg/ guest room/ day (Total 4240 kg/day) & 20 Lit/day		4240	20	20 lts per kg	@ 12 lts per kg		@ 8 lts per kg	@ 80%
					84800	50880		33920	67840
9	Gym and Spa	Total area= 1285 sq.m	918 @ 1.4 sq.m per person	15	@15 ltspcpd	@5 ltspcpd	@5 ltspcpd	@5 ltspcpd	@80%
					13770	4590	4590	4590	11016
	Total				**567160**	**290030**	**104790**	**172340**	**443528**

Table 3: Miscellaneous Water Requirement for Hotel

S. No.	Description	Total Number of Units	Total Population	Total Water Demand Per Person Per Day	Total Water Requirement	Domestic Cold Water Demand	Recycled Water Demand	Domestic Hot Water Demand	Flow to Sewer (80%)
				LPD	LPD	LPD	LPD	LPD	LPD
1	Make up water for cooling tower of A/C plant (330000 LPD)				330000		330000		
2	Landscapping water requirement for 30% of plot area = 0.3X22177 = 6653 sq.m @ 5 Lit / sq.m				33265		33265		
3	Road washing (L/S)				5000		5000		
4	Mopping & Washing				2000		2000		
5	Toilet Flushing	530	1060	60	@60 ltspcpd		63600		
					63600				
6	Swimming Pool (For Hotel) make-up water	Volume of the pool=305.099 X 2 = 610.198 cubic mtr. =610 cubic mtr. Appx			@ 0.625 ft. evaporative loss				
					58674	58674			
7	WTP backwash & regeneration				8000	8000			
	Total for Miscellaneous				**500539**	**66674**	**370265**	**0**	**0**
	Grand Total				**1067699**	**356704**	**475055**	**172340**	**443528**

Table 4: Total Water Requirement Chart

TOTAL WATER REQUIREMENT CHART		
	Total water requirement (KLD)	1067.699
	Total domestic cold water requirement (KLD)	356.704
	Total domestic hot water requirement (KLD)	172.34
	Total toilet flushing water requirement (KLD)	63.6
	Total landscapping& road washing water requirement (KLD)	38.625
	Total soft water requirement (KLD)	330
	Flow to Sewer (KLD)	443.528
	STP Capacity (KLD)	550

	Total Water Output from STP (KLD) @70%	385
	Total Recycled water requirement (KLD)	475.055
	Water Requirement from Municipal/Domestic/Tubewell for Recycle Purpose (KLD)	90.055
	Total Water Requirement from Municipal/Tubewell for Domestic+Recycle Purpose (KLD)	619.099

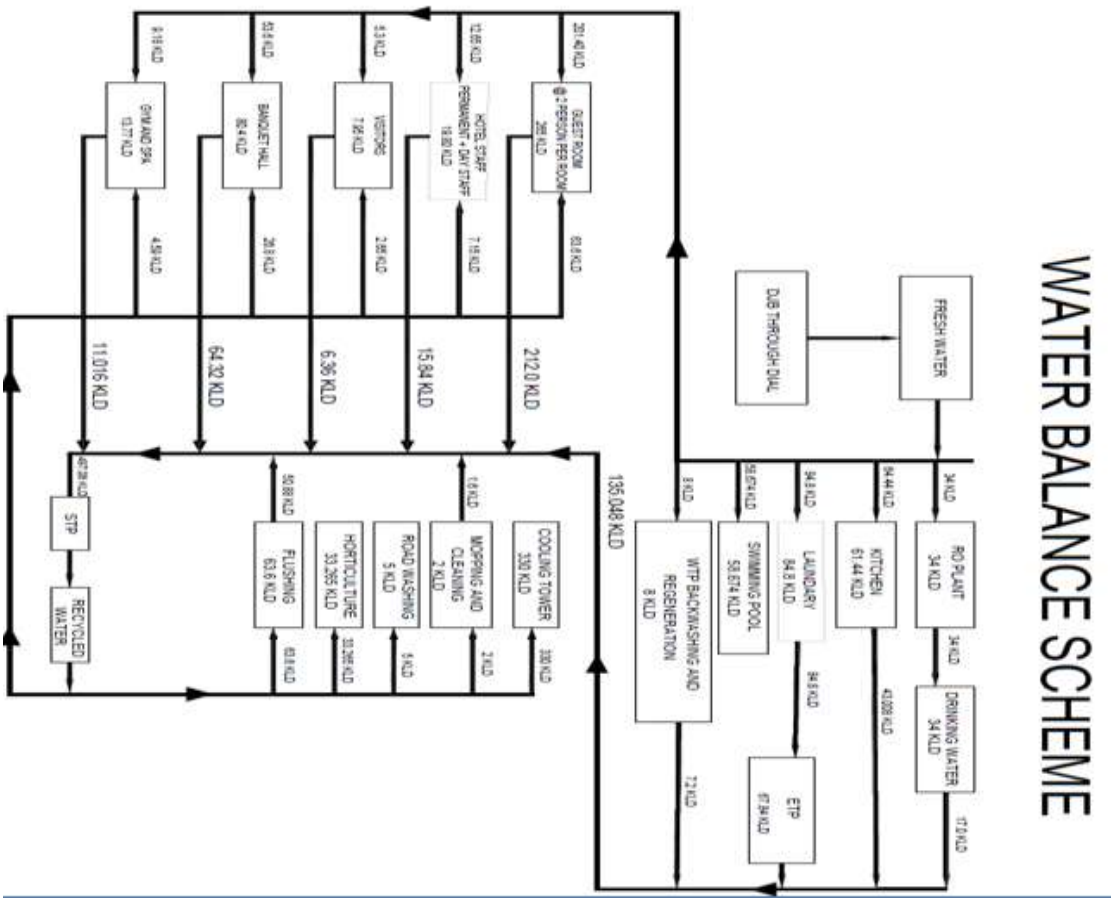

Fig 2: Water Balance Scheme

Considering water consumption about 90 % of water (i.e. WW) after suitable treatment at different stages is reused. From the present assessment it is found that very less waste is wasted and consumption (intake) of water from groundwater is drastically reduced by applying the concept of ZLD

III. CONCLUSIONS:

The concept of ZLD is technologically and economically viable option because of the present context of resource constraint – increasing non availability of water, and its rising cost. The prevention of pollution of water resources is, therefore, immensely needed to sustain life. The present study deals with the justification of this fact. The commercial & Industrial complexes consume and generate large quantity of water and wastewater The ZLD concept was applied in a 5– Star hotel in Delhi by means of adopting different wastewater treatment techniques and purification systems to achieve the fullest reuse of wastewater after treatment for secondary purposes as well as in the process such as boiler feed water and in cooling water system. Hence the quantity of fresh water required is drastically reduced. To implement the ZLD concept and to get the benefits as per the Cess Act of 1992, the industrial and commercial complexes are required to adopt suitable treatment systems to achieve the no discharge of wastewater

outside. This concept provides economic gain, health safety , and environmental protection.

REFERENCES:

[1]. Rao, C. S., (1995). Environmental pollution control engineering. Wiley Eastern Ltd., 301.)

[2]. G.Vishnu, S.Palanisam, K.Joseph(2007), Assessment of fieldscale zero liquid discharge treatment systems for recovery of water and salt from textile effluents, Journal of Cleaner Production 16 (2008) ,pp- 1081-1089

[3]. PawarAvinashShivajirao (2012), Treatment of Distillery Wastewater using Membrane Technologies, International Journal of Advanced Engineering Research and Studies, Vol. I, Issue III, April-June, 2012, pp-275-283

[4]. M. Panaitescu, F-V Panaitescu ,I-A Anton(2015), Theoretical and experimental researches on the operating costs of a wastewater treatment plant, IOP Conference Series: Materials Science and Engineering, Volume 95, conference 1

[5]. World first for zero liquid discharge Filtration+Separation January/February 2016, www.filtsep.com

[6]. F. Tillberg(2004),ZLD Systems – An Overview, Department of Energy Technology, Royal Institute of Technology, KTHStockholm,2004,http://www.xzero.se/doc/zldanover.pdf.

[7]. MovChimeng, (2014), Development of a Zero Discharge Approach for Cooling Tower Blowdown in Petrochemical Industry, A thesis submitted for the degree of Master of Engineering in Environmental Engineering and Management, Asian Institute of Technology, School of Environment, Resources and Development, Thailand, 2014

[8]. Jin Wang, QaisarMahmood, Jiang-Ping Qiu, Yin-Sheng Li, Yoon-Seong Chang, Li-Na Chi and Xu-Dong Li (2014) ,Zero Discharge Performance of an Industrial Pilot-Scale Plant Treating Palm Oil Mill Effluent, BioMed Research International, Volume 2015 (2015), Article ID 617861, 9 pages

[9]. SrinivasaraoGAngavarapu, Dr. Uma Maheswara Rao Ganguru, Sunil Kulkarni, Narasimha Murthy Brahmandam (2015), Studies on Zero Liquid Discharge (ZLD) plant in API Manufacturing Unit, International Journal Of Innovative Research in Engineering & Management(IJIREM0, ISSN: 2350-0557, Volume-2, Issue-5 , September 2015, pages 33-36.

[10]. Siddhartha Gautam, Sirajuddin Ahmed, Kafeel Ahmad and SanjoyMaji (2015) Advances in Applied Science and Environmental Engineering, Institute of Research Engineers and Doctors, pp- 52-56

A.Mubarak "Zero Discharge Concepts in Five Star Hotel – A Case Study "International Journal of Engineering Research and Applications (IJERA) , vol. 8, no.7, 2018, pp.13-20