HYDROSOCIOLOGICAL FRAMEWORK OF MAJOR INTEGRATED STEEL PLANTS OF INDIA.

ASOK KUMAR GHOSH

Former Technical Director & Head Water System M.N.Dastur & Co.

Former Consultant Tata Consulting Engineers

Presently External Examiner, Jadavpur University School of Water Resources Engineering

Kolkata India

Abstract - Water is one of the most useful resource for development in todays world. Water is also required for very existence of Human and other plant and living objects. However this important and essential resource has not been awarded any price value by our economists. This has resulted in serious wastage and pollution of this important resource. An integrated steel plant is a very important Component of development particularly for a large country like India .Since water was not awarded any price steel units constructed during 1950s were provided with captive water source with dam on a important river bodies and large quantity of water used to be consumed. Most of the plants constructed during 1950s used to consume 40 – 60 Cum of water for production of 1 ton finished steel. In addition these plants used to produce huge contaminants to pollute the nearby rivers and Strems. Of course the situation has changed significantly since 1990 modernization and expansion particularly because it was felt that additional water requirement for expansion can be met only from reuse of treated waste and effluent water .Presently 1 ton of water is expected to be produced through consumption of about 6cum of water in a Zero Discharge Plant. Environmental impact assessment studies and environmental management plan of integrated Steel Plant must be associated with extensive hydro sociological networking.

Index Terms: Hydro geomorphological Studies, Hydrogeological Studies, Zero Discharge, Mandira Dam, Tarkera, Steel Plant.

I. INTRODUCTION

Water is an essential resource for mankind. Water is essential for very existence of plant ,animal and human life on the face of the earth. Water is not only a resource it is a commodity for development and also an integral part of our environment and ecological set up. After second world war most of the countries in Asia took up large scale industrial development. Here we must remember that any development be it on industrial side, urban side or agricultural side need huge quantum pf water. In addition the population of India and other countries of Asia increased exponentially after second world war. All these brought huge increase in the demand of fresh water.During this period of development the most critical component of governance was chosen to be Economics and Finance. Here it appears strange that our stalwart and brilliant economists who were eager to mark prices of commodities like Gold, Diamond, Steel, Fossil Fuels did not dare to fix any price tag for essential resources like Soil and Water. India as a country originally governed by traditional values and protection of nature became a victim of fast development and attribution of excessive values to money power .This created a peculiar situation where water and soil are considered free and coal , iron ore, steel, fuels are considered hugely overpriced We not only started wasting our fresh water resources but also use our pious waterbodies for dumping our waste and effluent items. This criminal misuse of an important and essential resource like water has over the years created a horrible situation. In this paper this situation is analyzed with the use of integrated steel plant and demand of water for producing steel. The reason for selecting steel plant is that a steel plant requires huge water for production and that a steel plant produces large quantum of industrial polluted effluent .The subject needs elaborate point to point study of Hydro sociological parameters related to operative and maintenance related acytivites going on in an integrated steel manufacturing set up. As specific examples Sail and Tata Plants have been selected in general and Rourkela Steel Plant in Particular.

2. SITE SELECTION GREEN FIELD STEEL PLANT:

The Hydro sociological study for an integrated steel plant starts from the very first site selection investigation carried out at various alternative sites .The studies to be carried out at this stage cover Hydro geomorphological studies, Hydro meteorological studies, Soil Infiltration Studies, Rainfall-Runoff Studies, Hydrogeological Studies, Overall Drainage System, Drinking & sanitation System at the site and nearby population centers and also nearby water sources, water quality and water availability.

3. SITE SELECTION BROWN FIELD STEEL PLANT:

Integrated steel plants are capital intensive industries and most of the plants are expanded in different phases. During subsequent brown field expansion most of the studies indicated under Green Field Site Selection have to be carried out in addition to the drinking and sanitation system of the existing plant.

4. WATER REQUIREMENT OF INTEGRATED STEEL PLANT:

. Water is required in an integrated steel plant for equipment cooling and to meet some process needs,steam raising, for collecting and conveying scales, dust & debries In addition water is required to meet drinking and sanitation water requirement of the plant personnel. In addition water is required for floor washing, cleaning, dust suppression and to meet fire fighting requirement . water is also required to meet the requirement of plant greeneries. Since water requirement of integrated steel plant is very high as a practice recirculation system is adopted. Thus, whenever, we indicate water requirement of a steel plant we normally indicate make up water requirement. The actual water handled inside the plant is termed recirculation water .In order to understand and appreciate the necessity of water conservation of an integrated steel plant we have to analyze the water requirement of different units of an integrated steel plant. Table 1 presents the qualitywise recirculation and make up water requirement of a 3 million ton Integrated Steel Plant as prevailing in a typical design figures during the year 2010. In the present paper the year 2010 is chosen as a critical year because this can be taken as the mid point of the threshold of both steel production and water consumption for steel production.

TABLE 1 : QUALITYWISE WATER REQUIREMENT OF A 3 MILLION TON INTEGRATED STEEL PLANT:

Sr.No.	Consumers	Water in Circulation,Cum/Hr				Make-Up Water,Cum/Hr.			
		DM Closed	Soft Closed	ICW	DCW	DM	Soft	Ind. Water	Total
1.	RMHS			600				100	100
2.	Sinter Plant			1200				80	80
3.	Coke Oven & By Product Plant			10000	1000			350	350
4.	Blast Furnace	6600	4400	12000	7000	30	20	675	725
5.	Pig Casting Machine				1000			100	100
6.	Converter	3300	1500	2250	1050	10	5	100	115
7.	Laddle Furnace		1000	1200			5	30	35
8.	Calcining Plant			400				25	25
9.	Oxygen Plant			6000				150	150
10.	Billet Caster	75	1150	1300	600	1	4	60	65
11.	Thin Slab Caster		2500	8000	15000		10	575	585
12.	Wire Rod Mill			1600	1800			120	120
13.	Rebar Mill			1600	1800			120	120
14.	Power Plant & Turbo Blower			22000		200		440	640
15.	Drinking & sanitation							200	200
16.	Plant Greeneries							80	80
17.	Miscellaneous Consumers							40	40
18.	Loss in Storage							180	180
19.	**TOTAL**								**3710**

Table 1 shows that good quality water (Demineralized & Soft) is required for equipment cooling so that life of the equipment can be enhanced. The total make up water requirement has been estimated as 3710 cum/hr. This shows that a make up water requirement at about 10 Cum per ton of finished steel. With this make-up water consumption the effluent generated from blowdown and conventional waste water treatment plant is estimated at about 1225 cum./hr. This is the scenario in the year 2010. However there is continuous improvement in achieving conservation of water in integrated steel plant. A deeper analysis of water requirement for integrated steel plant needs a look to the process aspects of steel making. Steel making Is involved with high temperature process rrot and needs cooling as a major process tool. Table 2 presents the energy loss in an Integrated steel plant of 2 MTPA.

TABLE 2 : ENERGY LOSS OF A 2 MILLION TON INTEGRATED STEEL PLANT:

Sr.No.	UNIT	AIR COOLING & UNACCOUNTED	STACK GAS	WATER COOLING	TOTAL
		GCALORIE/YEAR	G CAL/YEAR	GCAL/YEAR	GCAL/YEAR
1.	COKE OVEN	974471	230406	1845365	3050241
2.	SINTER PLANT	1190519	180462	NIL	1370981
3.	BLAST FURNACE	472400	301342	1483834	2257576
4.	CALCINATION	112712	37149	NIL	149861
5.	PIG CASTING MACHINE	4507	NIL	18030	22537
6	STEEL MELT SHOP	817780	37500	243370	1098650
7	CASTING	305909	NIL	299298	605207
8	HOT STRIP MILL	625125	150616	140336	916077
9	COLD ROLLING MILL	354641	51388	NIL	406029
10	TOTAL GCAL/YEAR	4858064	988862	4030233	9877159
11	GCAL/TON	2.429032	0.494431	2.015117	4.93858

The water consumption on material and energy balance basis can be summarized as follows:

1. The theoretical make up water requirement works out to 5.25 cum/ ton.
2. Water consumption to dissipate heat generated from electrical energy is estimated at 0.2 cum/ton of steel.
3. For drinking and sanitation of plant personnel and various miscellaneous consumers a provision can be made for 0.5 cum/ton of steel.
4. For a captive power plant of 3 X 67.5 MW for 3 MT plant the estimated water consumption per ton of steel works out to 2.7 cum/ton of steel.
5. For a captive oxygen plant of 2 X 500 TPD the water consumption works out to 0.25 cum/ton of steel.

5.PRODUCTION OF STEEL IN INTEGRATED STEEL PLANTS IN INDIA

During the year 1947 – 1950 the total steel production in India was about 2 million ton per year(mtpa).Tata Steel (TISCO)and Indian Iron & Steel Co Ltd (IISCO) were the major steel producers and both were in private sector. With the formation of Planning Commission and major participation of Public Sector Hindustan Steel Ltd was set up in the year 1954 and three major integrated steel Plants were commissioned at Durgapur, Rourkela and Bhilai in the year 1962. . Later Bokaro Steel was added in the year 1964.
Steel Authority of India was set up in the year 1973 as a holding company for all the above four integrated steel plants. Later Rashtriya Ispat Nigam Limited was set up in the year 1982 and Visakhapatnam Steel Plant was commissioned as the first shore based Steel plant in the year 1990.In 1991 the steel sector was liberalized and private sector was invited to enter steel sector.
Since then there is a steady surge of steel production in India. During 1991 the steel production was 17 MTPA (million ton per year). In the year 2001 the production reached 27 MTPA. During the next two decades the production increased four times and reached 108MTPA in the year 2018 and India became the second largest steel producer in the world. The present steel production is about 120 MTPA. When the first four integrated steel plants were conceptualized the importance of water as a resource and environmental Component was not visualized and the steel plants were attached to a captive water source with a dam on a perennial river. Since steel Production was nominal and shortage of water was not a factor the consumption of water (make up water) for one ton of finished steel Was 30 to 60 cum . This situation continued upto 1985. When initially Vizag Steel Plant was designed with adoption of enhanced Recirculation system the consumption figure was brought down to 15 Cum per ton of finished steel. During this time Tata Steel also Embarhed on major expansion and with water conservation measures the make up water was brought down to 15cumper ton Of finished steel. In the year 1990 when major modernization and expansion programmes were undertaken in SAIL plants a new scenario Emerged with the introduction of Environmental Impact Assessment studies for steel plant expansion programmes. Parallelly shortage Of water for different sectors was also felt and became an important indicator for overall planning process. During this period a Comprehensive report on Environmental Impact and Environmental Management was prepared by M.N.Dastur & Co. consultant of Vizag Steel Project. Before modernization the make up water consumption of Rourkela Steel Plant was about 60 Cum per ton Of finished steel. Between 1990 and 2010 this consumption figure was gradually brought down to 10 – 15 cum per ton in the year 2010. During 2010 to 2022 this figure has gradually been brought down to about 5 cum per ton of finished steel through adoption of Zero Liquid Discharge, Rainwater Harvesting and Reuse of Treated Sewage water.

6. RECIRCULATION SYSTEMS:

The first step towards conservation of water in an integrated steel plant needs adoption of Recirculation System. In order to Understand and appreciate the usefulness of a recirculation system we have to start with an once through system shown in Figure 1. The recirculation systems utilized in a steel plant can be classified as Clear Water Circuit or indirect cooling water circuit and direct cooling water circuit or contaminated water circuit. The clear water circuit can be either a fully closed water circuit with recirculation(of specially treated water) through heat exchanger or an indirect cooling water open circuit with cooling in cooling tower. The direct coolong water circuit or contaminated water circuit needs inclusion of a contaminated water treatment plant and a cooling tower to achieve both cooling and treating the water to produce a reasonably clear quality water for recirculation. .The various typical recirculation systems like cooling pond system, clear closed cooling system and clear and contaminated circuits are presented in Figure 2,Fig 3, Fig 4 and Fig 5 illustrated below.

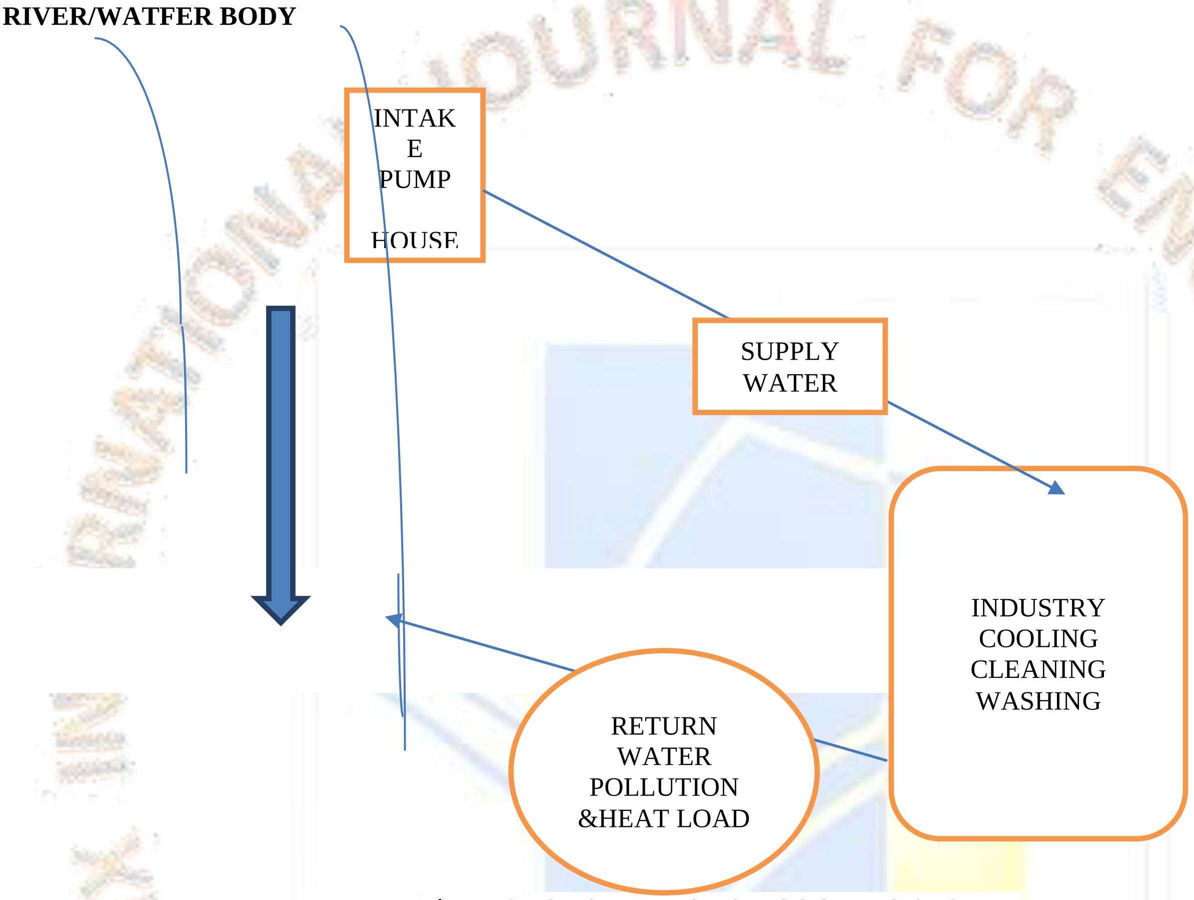

Figure 1 : ONCE THROUGH COOLING SYSTEM

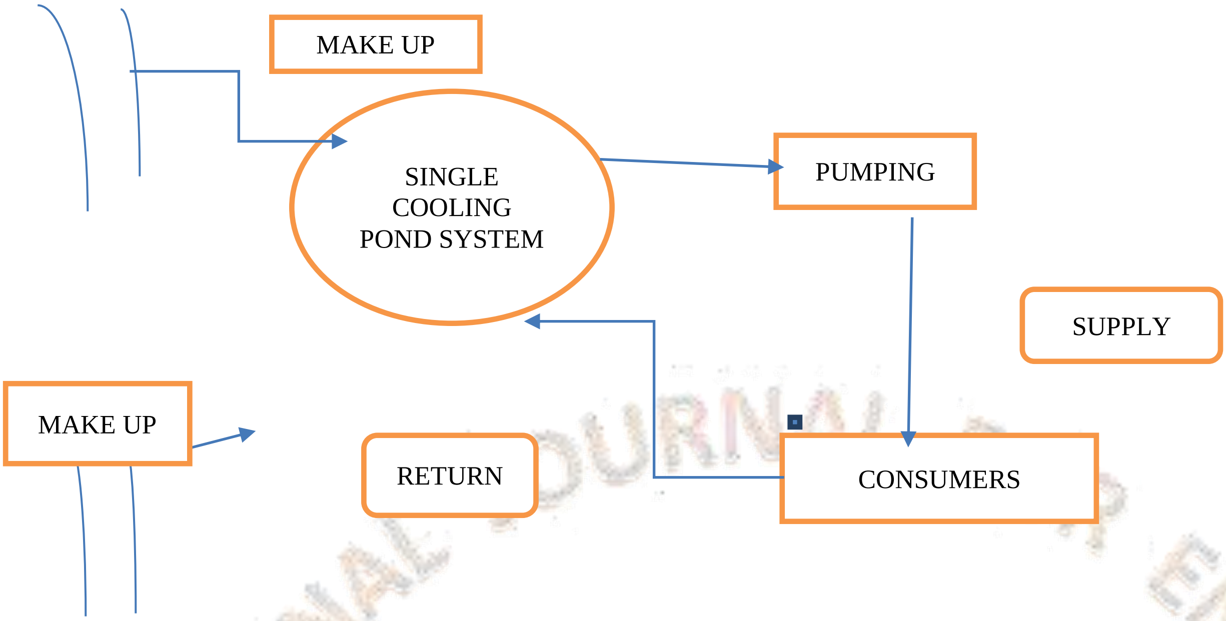

FIGURE 2 SINGLE COOLING POND SYSTEM

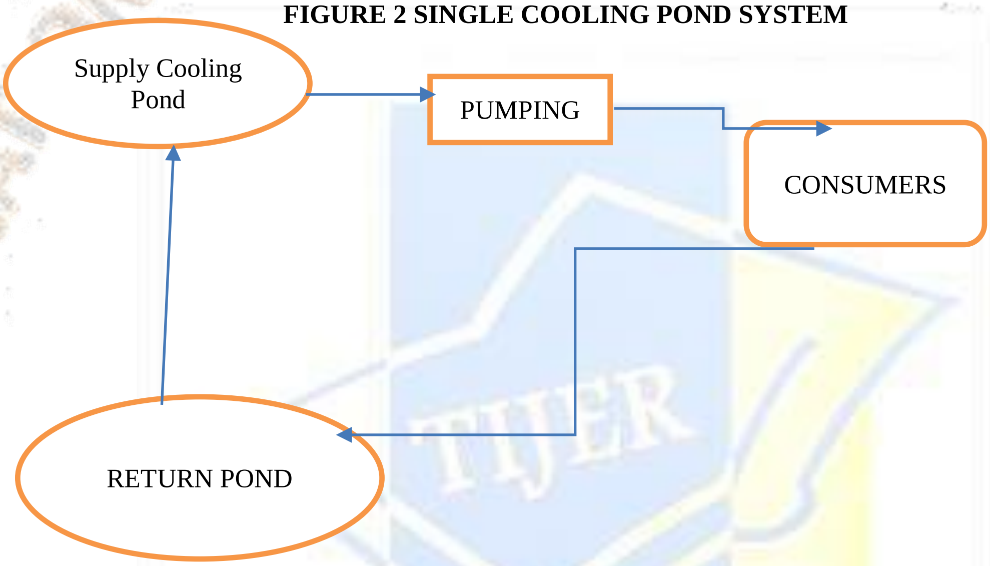

FIGURE 3 DOUBLE COOLING POND SYSTEM

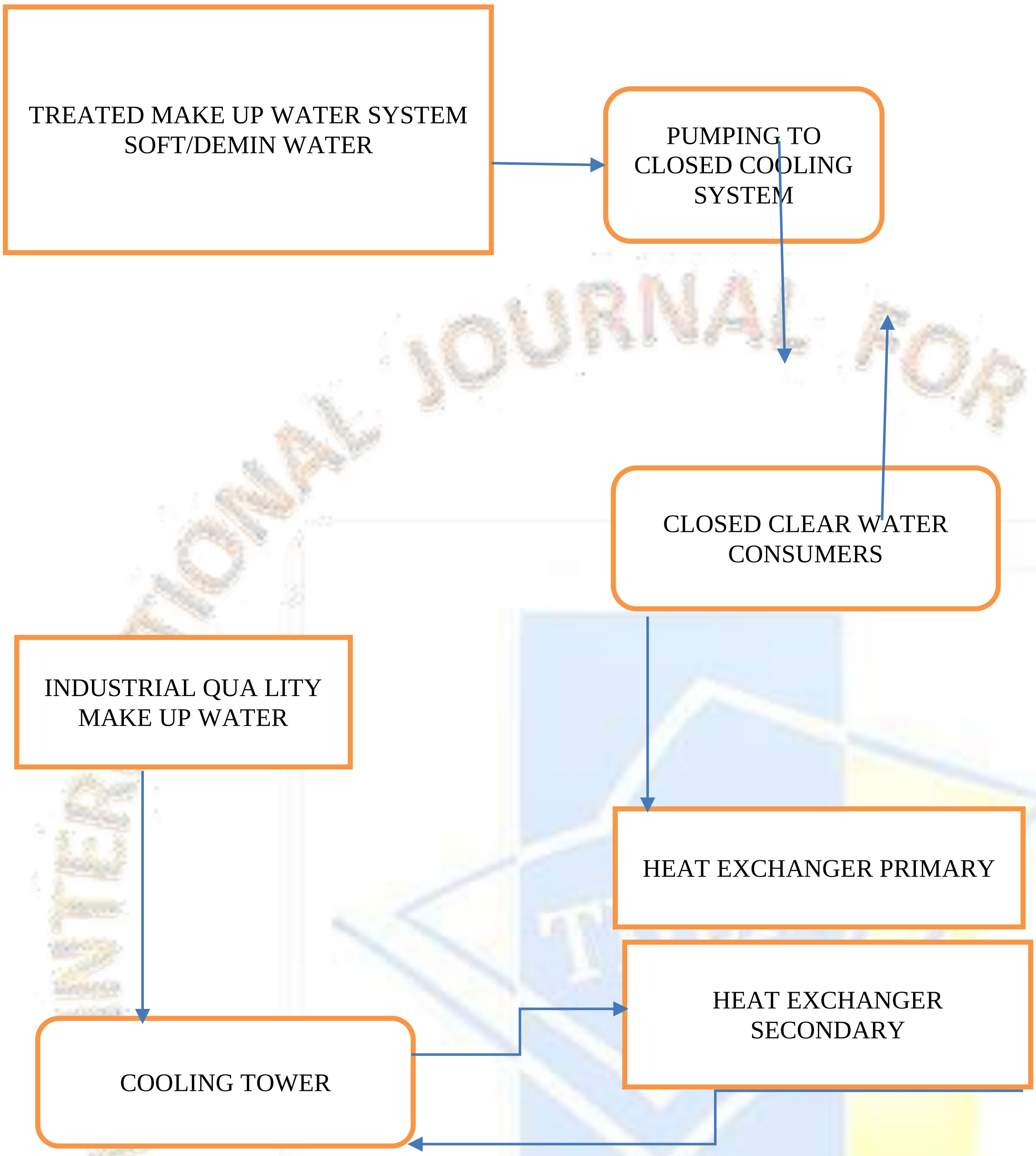

FIGURE 4 CLOSED CLEAR WATER COOLING CIRCUIT.

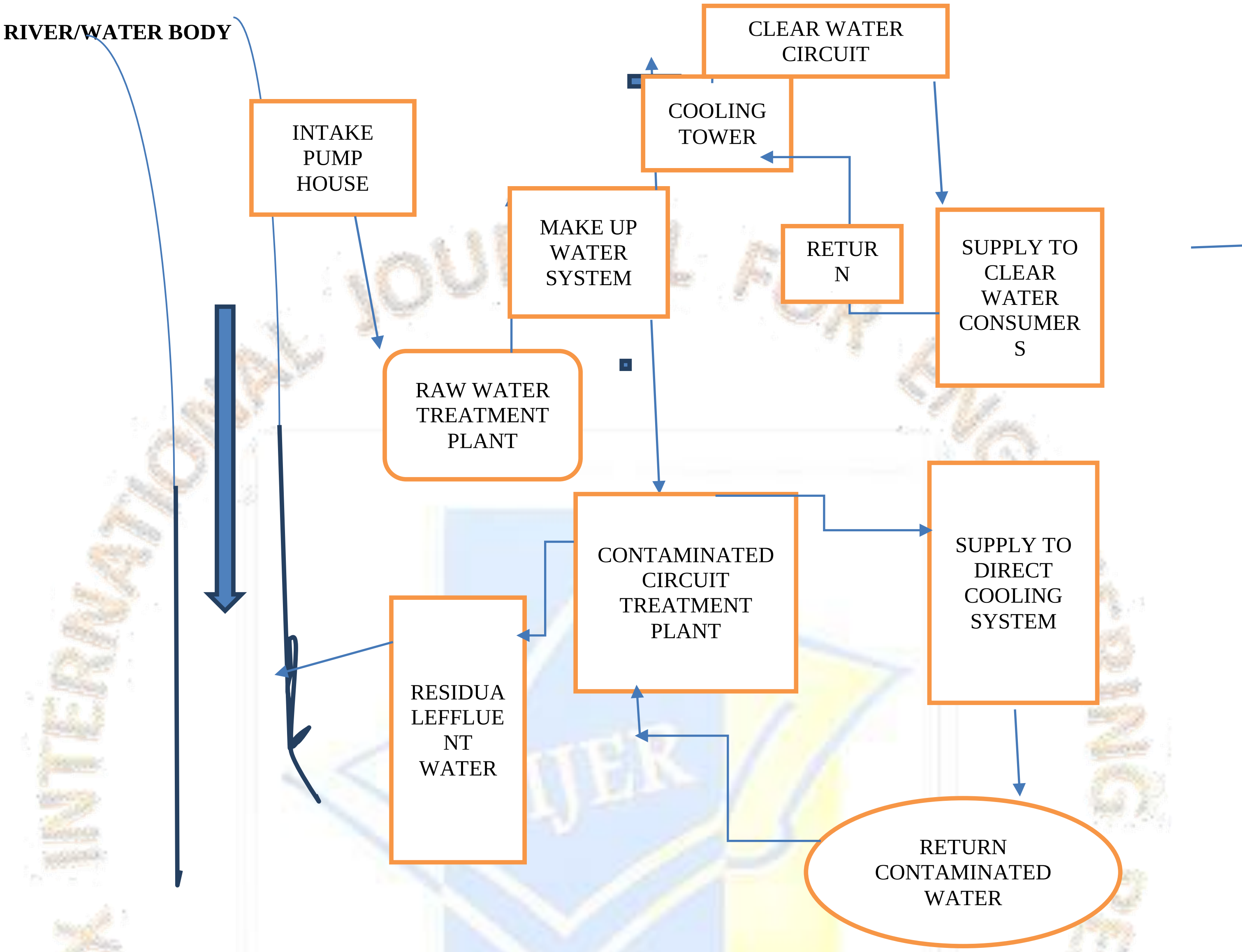

FIGURE 5 TYPICAL CLEAR (INDIRECT) COOLING CIRCUIT & CINTAMINATED (DIRECT) COOLING CIRCUIT

7. SLUDGE DEWATERING AND SLUDGE THICKENING SYSTEMS :

The sludge produced in the raw water treatment plant and contaminated water treatment plant produces large Quantity of sludge containing solid and water. It is very difficult to handle this sludge for disposal .Hence sludge dewatering and Sludge thickening systems need to be adopted so that the maximum quantum of water is extracted for reuse and reasonably dried solid waste may be disposed of.. The various sludge thickening equipment used in steel plant are disc filter, drum filter, filter press, hydro cyclone, and pressure filter .

8. HYDROSOCIOLOGIC FEATURES OF ROURKELA STEEL PLANT :

Rourkela Steel Plant is located in the Sundargarh district of Odisha India. The plant is located on the bank Of the river Brahmani. The river Brahmani originates at the confluence of rivers South Koel and the river Sankha. To prepare Rourkela for an industrial complex, more than 30 villages were displaced to acquire about 19,722 acres of land in 1955. Later parts of Bondamunda village were acquired for the marshalling yard for of the steel plant. (Wikipedia , Rourkela Steel Plant).To provide sufficient water supply for running the steel plant, the **Mandira Dam Water Reservoir** was constructed near Kansbahal, on the banks of the river Sankha The first notifications for vacation of land for the dam site were issued in 1957..The first Prime Minister of India persuaded villagers to give their lands and assured them that the displaced would be compensated.Mandira Dam was set up on about 11,923 acres of land acquired from 31 tribal villages, which were then submerged under water. The construction of the dam was started in the year 1957 and completed in 1959. (Wikipedia Rourkela Steel Plant 2023).Figure 6 presents a sketch of the Mandira Dam (Wikipedia).An intake works was constructed at Tarkera on the river Brahmani for pumping make up water to Rourkela Steel Plant. During dry season water is released from the Mandira Dam to augment water and raise water level at Tarkera .Till the first modernization i.e upto 1 MTPA stage most of the contaminated circuit effluent used to be sent to a lagoon for final discharge to the river Brahmani.This disposal of polluted effluent in the river Brahmani had a very bad effect on the fish population and irrigation activities by local population. However during subsequent modernizations withextensive treatment of effluent and reuse of treated water the make up water requirement was reduced and the pollution level of effluent was reduced to the minimum. The intake water system is simply pumping of raw water from river and raw water treatment during rainy season to get rid of suspended solid. For soft water and demineralized water special treatment is necessary . However the waste water and effluent treatment is a much more complicated subject and needs detailed analysis and research . Achieving zero liquid discharge in an integrated steel plant needs detailed investigation. Thus a robust hydro sociological management in an integrated steel plant can source additional water for future expansion and also can reduce pollution level.

The Business BYTES(January 10 2022) presents this attempt to implement Zero Discharge in the Rourkela Steel Plant during future expansions.As a part of its commitment to the cause of environment, Rourkela Steel Plant (RSP) has been making every effort to reduce, treat and reuse its effluent water. Besides, the Steel Plant is currently implementing various projects to achieve the objective of becoming a ‘Zero Discharge’ Plant.RSP has adopted a multi-stage treatment strategy for treating its waste water before discharging into River Brahmani. The waste water generated from various units of RSP is first treated at their source of generation in the dedicated Waste Water Treatment Plants (WWTP) installed at different departments. The treated effluent is then discharged to ‘Guradhi Nallah’ through 9 outfalls. The total effluent is then taken to a ‘Lagoon’ which is an Oxidation Pond for secondary treatment. RSP has constructed a shallow oxidation pond called Lagoon spread over 52 hectares of land which was designed and constructed under the guidance of NEERI, Nagpur. The water is retained in the lagoon for 4-5 days during which the pollutants are treated naturally by photochemical reaction in presence of aerobic and facultative bacteria. After treatment the water is discharged into River Brahmani through Lagoon outlet. The quality of finally treated water discharged into the river is well within the statutory norms in all the times.

Work is now going on in full swing to desilt the lagoon by evacuation of 3 lakh cubic metre of silt using dredging/mechanical excavation. After desilting of the Lagoon, there will be a clear water body spreading over an area of around 20 hectares which will add to the biodiversity and aesthetics. The project being implemented at a cost of Rs. 23 crore is expected to be completed this year.

Additionally, RSP has also adopted Biological treatment in BOD Plant for Coke Oven effluent. The treated water from BOD Plant is recycled back to Coke Ovens for its utilization in coke quenching. At present, Modernisation of BOD Plant on ZLD concept is also in progress. The project is being executed at a cost of Rs. 34 crore, and is likely to be completed this year.

Besides, a Sewage Treatment Plant (STP) is being installed at the Outfall #7 that handles the discharged water from canteens, washrooms and toilets. This project being executed at an expenditure of Rs. 15 crore, too is planned to be completed in the current year.Another project under implementation is the ‘Total treatment of effluent coming from Outfall#1.’ Under this scheme, the total effluent coming out from the Steel Melting Ship-2 and channeled through Outfall #1, will be treated in a dedicated Waste Water Treatment Plant with latest technology viz., HRSCC and RO systems so that the quality of the treated water can match with makeup water. This water will be reused in the steel making process.

The 3-Million Ton Hot Strip Mill that is in the process of stabilization, functions entirely on Zero Liquid Discharge concept. The Mill lifts water from the lagoon and uses it after recycling the same. All the equipments are designed to reuse this water so that there would not be any liquid discharge from this state-of-the-art unit.

Notably, RSP conducts regular monitoring of the final effluent discharged from the Lagoon outlet to River Brahmani. Besides a Continuous Effluent Quality Monitoring Station has been installed at the Lagoon outlet which continuously analyses the effluent quality and the measured parameters are uplinked with the server of State Pollution Control Board, Odisha.

FIGURE 6 MANDIRA DAM ON RIVER SANKHA (Wikipedia Rourkela Steel Plant)

9. HYDROSOCIOLOGICAL FRAMEWORK OF INTEGRATED STEEL PLANT

Construction of Hydro sociological framework of an Integrated Steel Plant starts from site selection of the plant. An integrated steel plant needs a large piece of land with topographic variation and a general drainage character And all these are affected due to site levelling and site pavement to accommodate various shops and units and Offices. Conveyance between these units need elaborate road and railway network. All these shops and pavements bring significant impact on the infiltration characteristics and recharge to ground water aquifer. Huge quantity of dust is generated during construction and also in operation stage of an integrated steel plant. Dust suppression activities need significant quantity of water.

Cooling of furnaces and cooling of hot product need large quantity of water. Part of this water gets evaporated and part contaminated with pollutants .Treatment of waste water produces large quantity of sludge. Since the make up water is drawn from local fresh water source other regional consumers of fresh water suffer. Figure 7 presents a generalized Framework of Hydro sociological features of an integrated steel plant .

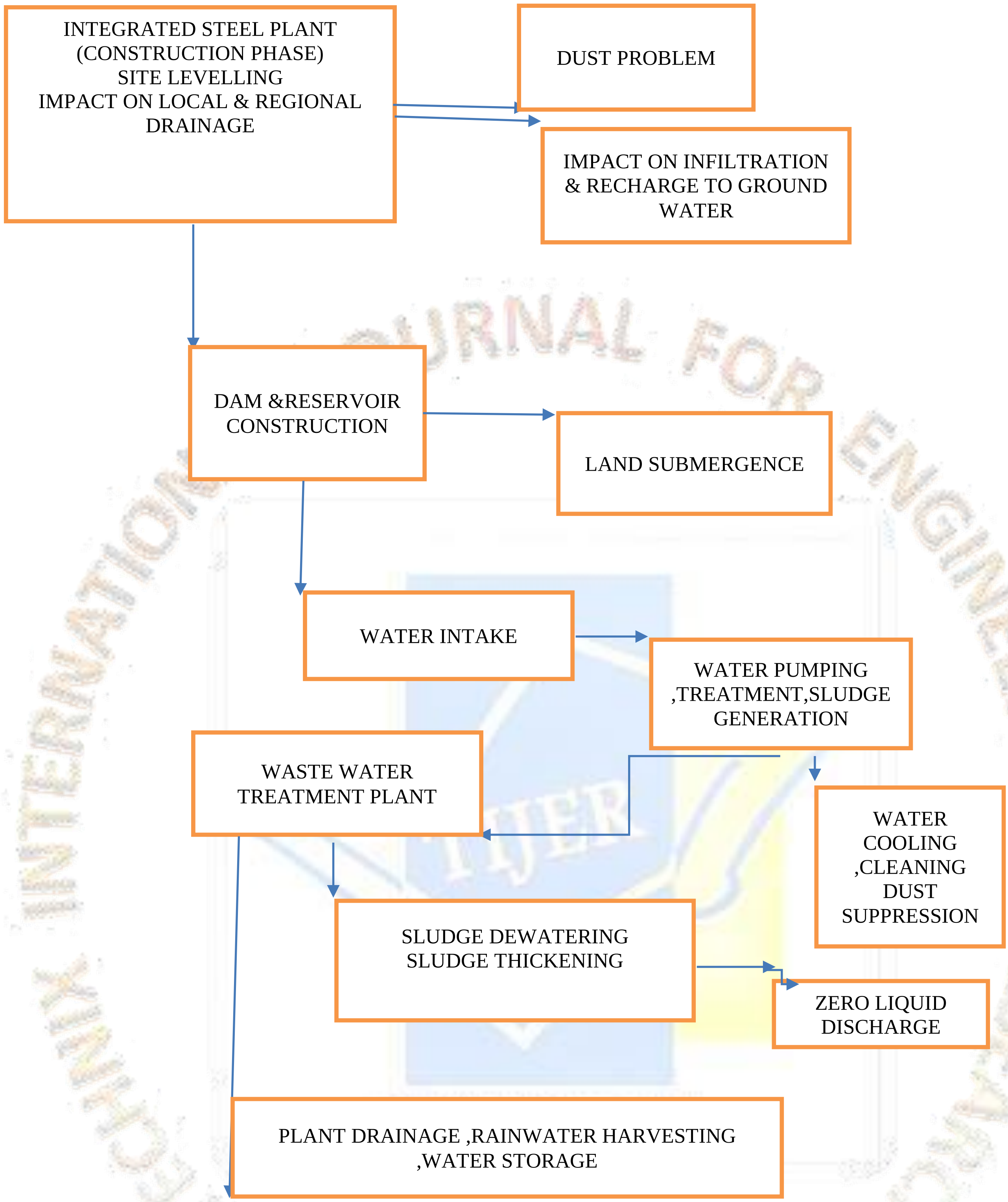

FIGURE 7 HYDRO SOCIOLOGICAL FRAMEWORK OF INTEGRATED STEEL PLANT

ACKNOWLEDGEMENT:

The concept of this paper originated during the authors consultancy job at M.N.Dastur & Co.Kolkata. The author got the inspiration from his departmental seniors Late Srimanta Mukherjee, Late Shibnath Bose and Late Mahima Ranjan Santra . . The inspiration for GeoHydro related concepts can be attributed to Prof Dr Adrian Eugene Scheidegger during the authors PhD work in the University of Illinois USA.

REFERENCES :

1. Wikipedia Mandira Dam, Tarkera,Sankh River
2. The Business Bytes Rourkela 2022.