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Planning & Design of Hydro–Landscape with Special Reference to Zero Discharge in Industrial Setups in Faridabad

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Abstract:
Water is a life sustaining element. While it is rather hard to imagine life without water; the times we live in are faced with the distressing and alarming reality of water scarcity& widespread pollution of water sources. Today's times are challenging & the widespread water woes, are therefore a concern of professionals from varied spheres of life be it hydrologists, engineers, architects & landscape architects. Water experts everywhere are advocating the process of water harvesting—capturing, diverting and storing non-potable, or "reclaimed" water for landscape, irrigation and a variety of other uses. In keeping with the concept of zero discharge, harvesting rainwater and storm water can greatly reduce the possibility of damage from flooding and erosion at building sites. Furthermore, the water available from water harvesting can be used effectively as a resource to create anaesthetic landscape and thermally comfortable spaces. The said concept has been demonstrated through a case study. The case study of M/s Escorts private ltd, Faridabad occupies an area of 27 acres & has a freshwater demand including that of office workers & floating population equal to82.5 cu metre/day. This demand can easily be met from the existing four tube wells at site. Further, the horticulture & landscape irrigation demand equals50 cu metre/day. At present, the total demand of water is 132.5 cubic metre/day; of which 103.96 cu metre is being abstracted from the tube wells & the stage of ground water development as per ground water estimation committee, 2006 equals to127 % which is categorized as a black site area as per the NABARD norms. It is rather alarming to note that the water level has already acquired a declining trend in the study area. The failure of water bodies is an obvious consequence but the loss of biodiversity though not that evident as of now is bound to have far reaching consequences. For, many plant species, either has been eradicated completely or is on the verge of eradication. This trend is not only creating implications for the biodiversity, but will eventually affect human health. For, the non-absorption of suspended particulate matter owing to the eventual extinction of plant species will lead to increased pollution in water. The present study thus is an attempt to provide remedial measures for the improvement of the stage of ground water development by virtue of providing the required planning and design of the hydro landscape. The proposed design of the hydro landscape will not only reduce the stage of ground water development from 127% to 75% but also provide guidance in terms planning criteria in an industrial sector like this to achieve zero discharge. This will further contribute to the adoption of a futuristic approach for cleaning of rivers in India in general & Yamuna River in particular. The present study "Planning & Design of Hydro–Landscape with special reference to zero discharge concept in Faridabad Region" will also be useful to planners, landscape architects, architects, engineers, scientists & other concerned administrators, bureaucrats working in this direction.

Key words: *Zero discharge, Recyclable potential, Rain water harvesting*

1. Introduction

1.1. General

Groundwater resource is a replenishable but finite resource. Over abstraction of ground water & uneconomic development of surface & ground water resources is adding to the water woes of all urbanized areas. The rapidly declining ground water, ever-increasing water demand, inefficient water distribution systems, water & energy intensive landscapes, discharge of pollutants etc present a rather gory picture. The situation is rather alarming in all urbanized areas & industrial towns. Faridabad presents a unique case in point.

1.2. Faridabad- A brief Profile

Faridabad district of Haryana located on southeastern part of Haryana state lies between 270 39’, 280 31’ north latitude and 76040’ and 77’32’ east longitudes. In the north, it is bordered by the Union Territory of Delhi in the east by Uttar Pradesh, in the North West by Mewat Gurgaon districts of Haryana. Total geographical area of the district is 2151 sq. km. It is situated on the Delhi – Mathura National Highway No. 2 & lies at a distance of 32 km. from Delhi. The town is bounded on the west by the Aravali Hills. The Yamuna flows very near to the city at its northern side and moves away as it goes south. Faridabad district is divided in to five Blocks, namely, Faridabad, Ballabgarh, Palwal, Hodel and Hassanpur and four subdivisions. Faridabad, town is the headquarter of the district.

1.2.1. Climate & Rainfall

Faridabad town experiences a semi-arid climate that is characterized by wide temperature variations and scanty and irregular rainfall. During summer, temperature may reach upto 450 C in June while in winter it drops to 1.90 C in February. May and June are the hottest and driest months, when dust storms from the west prevail with high speed. The average wind velocity is 2.1 km./hours during June and 1.3 km./hour during November. The relative humidity is maximum during August (upto 84 percent) and minimum during May (upto 16 percent).[1]

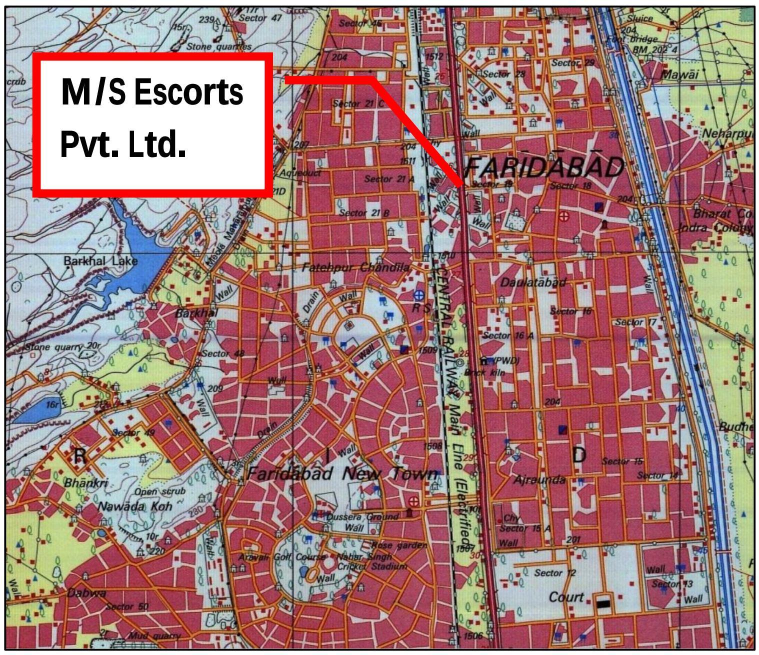

Figure 1: Location of Project area. Source: Toposheet Survey of India

1.2.2. Geography & Geology

Quaternary Alluvium consisting of sand, clay and silt underlies the major part of Faridabad city. In the western and northwestern part of the town, the quartzite ridges of the Delhi system can be observed. Along the Yamuna flood plain towards the eastern part of the town, the younger alluvium is mainly sandy with a thickness of about 10-15 m. The main water-bearing horizons (aquifers) consisting of a sandy layer is generally confined to 60m below ground level

1.2.3. Description of Study Area

The Corporate Centre of M/S Escorts Ltd is located at Faridabad, in Haryana district. The site is found to be an industrial complex. As shown in Fig 2 the area is spread over 27.0 acres where some area is occupied by roads with major buildings with vast development as horticulture block, while the complex is covered at two sides by forest.

[1] City Development Plan of Faridabad

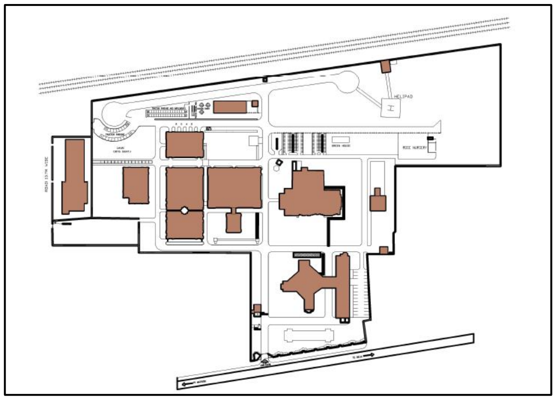

Figure 2: Site plan of project area. Source: M/S Escorts Pvt. Ltd.

2. Objectives of the Study

- To analyze the four stages of groundwater development of the project area using NABARD's norms in its present condition.
- To find out the parameters for the water losses in different parts of project area.
- To suggest, the improvement of the various stages of ground water development with conservation techniques.
- Finally, to suggest the design of hydro landscape in order to provide thermal comfort in the project area vis-a-vis water conservation.

3. Material & Methods

To achieve the main objectives of the study the following methodology was adopted:

- To calculate the draft water requirement of the area, population of the employees& the floating population have been considered along with other related parameters such as horticulture, processing demand etc.
- The calculation was made as per IS- 1172& NABARD's norms.
- Further, to improve the stage of groundwater development/RWH& recycling along with dry land plants were suggested to improve the availability along with the ground water. This also reduced the burden of aquifer system, which is very strained at present.
- The hydro- landscape design has been suggested to improve the stage of groundwater development at site & enhance the thermal comfort in keeping with the zero discharge concepts.

4. Analysis & Discussion

Optimum economic development of water resources in an area requires an integrated approach that coordinates the use of both surface water and groundwater resources. After the evaluation of total water, resources available and the water demand only, decisions regarding the sustainable utilization of water resources at site can be taken. Therefore, it is extremely essential to explore and assess the available water in the light of its withdrawal and recharge.

Further, the conjunctive use of water involves the coordinated and planned operation of both surface water and groundwater resources to meet water requirements in a manner whereby water is conserved. Coordinated use of surface water and groundwater does not preclude importing water, as required, to meet growing needs. The basic difference between the usual surface water development with its associated groundwater development and a conjunctive operation of surface water and groundwater resources is that the separate firm yields of the former can be replaced by the larger and economic joint yields of the latter. The procedure requires careful planning to optimize use of available surface-water and groundwater resources & water demand. Therefore, water demand has been assessed in the said case study based on the climatic conditions, habits of people, efficiency of water supply systems & quality of water.

4.1. Water Demand

Water Requirement of M/S Escorts pvt.ltd.
No. of Employee= 45 x 1500 = 67.5 cu metre/day
Floating Population demand = 15 cu metre/day
Horticulture + Landscaping = 50 cu metre/day
Total Water Requirement = 82.5 cu metre/day + 50 cu metre/day =132.5 cu metre/day

4.2. Ground Water Resource

In order to tap the groundwater and utilize it efficiently an in-depth hydro geological study needs to be undertaken. Hydro-geological studies for the study of the depth to water level, water level fluctuation and groundwater movement direction as well as groundwater quantity and quality potential are required in order to locate the infiltration wells. The ground water movement direction also needs to be ascertained in order to locate the infiltration wells in the upstream areas and the tube wells in the downstream areas in order to suffice the water demand.

4.3. Ground Water Resource Potential Map

The analysis of the groundwater resource potential map suggests three types of potential, which are as follows:

- Low Quality Potential
- Medium Quality Potential
- High Quality Potential

Low ground water resource potential lies towards the Railway Line & increases towards Mathura road. However, the medium quality potential lies between the low & the high quality potential zone as indicated in the map.

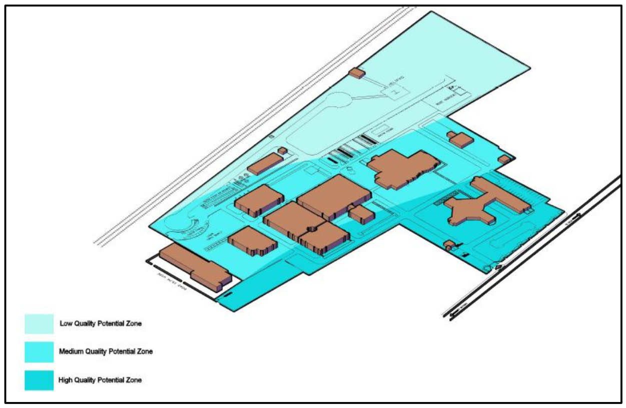

Figure 3: Ground water resource map, Source: Authors

4.4. Ground Water Available

Q gw = Area x water level fluctuation x Specific Yield

27 x 4048 x 3.1x16/100 = 54210cu meter/ yr

Q rr = 70/100x 54210 cu metre/year = 37947 cu metre/yr = 103.96 cu metre/day

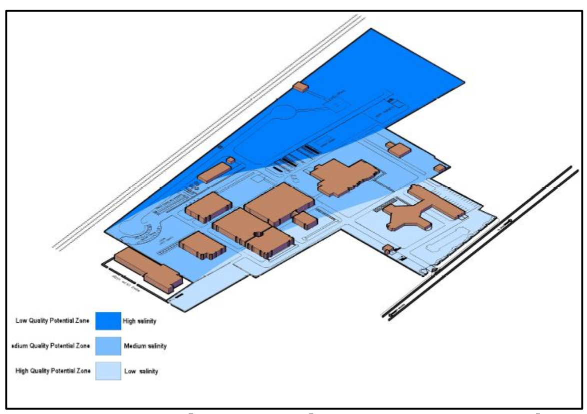

Figure 4: Ground water quality map, Source: Authors

4.5. Ground Water Quality Map

The analysis of the groundwater quality map suggests three zones based on salinity, which are as follows:

- High Salinity
- Medium Salinity
- Low Salinity

High Salinity is found towards the Railway line. The salinity decreases towards Mathura Road side for the water bearing strata, is towards Mathura road while less water bearing strata is encountered towards the railway line. The problem is further aggravated due to declining of water level.

4.6. Drainage Pattern & Density

Three types of density zones have been identified as the following:

- Low Drainage Density

- Medium Drainage Density
- High Drainage Density.

The Drainage density increases towards Mathura road making it more water bearing.

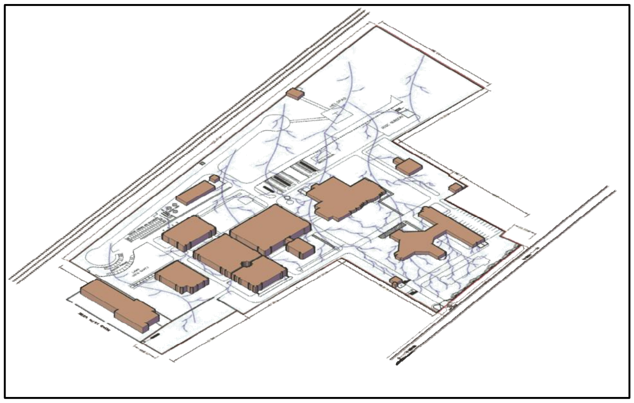

Figure 5: Drainage pattern and density, Source: Authors

4.7. Lineament Density Map

Three types of zones are identified which are as follows:

- Low Lineament Density
- Medium Lineament Density
- High Lineament Density

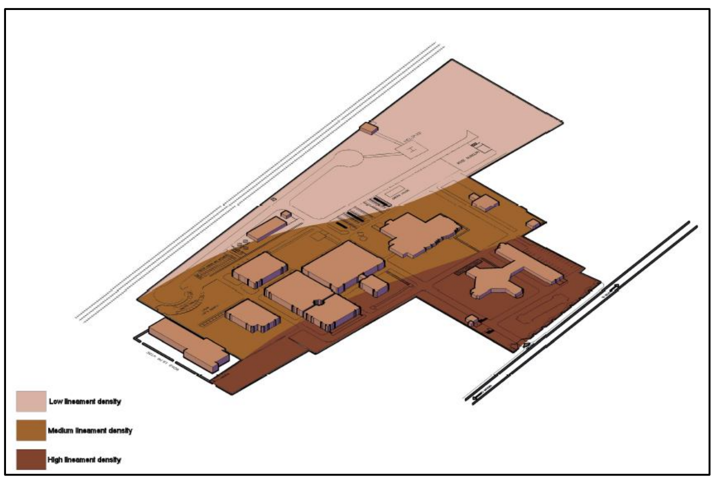

Figure 6: Lineament Density map, Source: Authors

4.8. Fence Diagram

The three dimensional view of the subsurface strata analysed using satellite interpretation reveals that there exist four types of strata, which are as follows:

- Top Soil Formation
- Weathered Rock Formation
- Fractured Rock Formation
- Solid Rock Formation
- Top Soil Formation occupied by thick layer from 30 – 60 MTRs is observed in the eastern part of the area close to Mathura road and it is thinning towards railway line where it contains 22 – 40 MTRs. with boulders intercepts. The water bearing strata lies closer to Mathura road area as depicted in the fence Diagram.
- Weathered Formation occupied by thick layer 20-30Mtrs is observed in eastern Part of the area close to Mathura road and it is thinning towards railway line where it contains 10 – 15 MTRs. The water bearing strata lies closer to Mathura road area as depicted in the fence Diagram.
- Fractured rock formation occupied by thick layer 20-25Mtrs is observed in eastern Part of the area close to Mathura road and it is thinning towards railway line where it contains 5 – 10 MTRs. The water bearing strata lies closer to Mathura road area as depicted in the fence Diagram.

- Solid Rock Formation is 40 Metre. Onwards in the eastern part of the area close to Mathura road and it is thinning towards railway line where it contains 10 MTRs onwards. It is a non-water bearing strata.

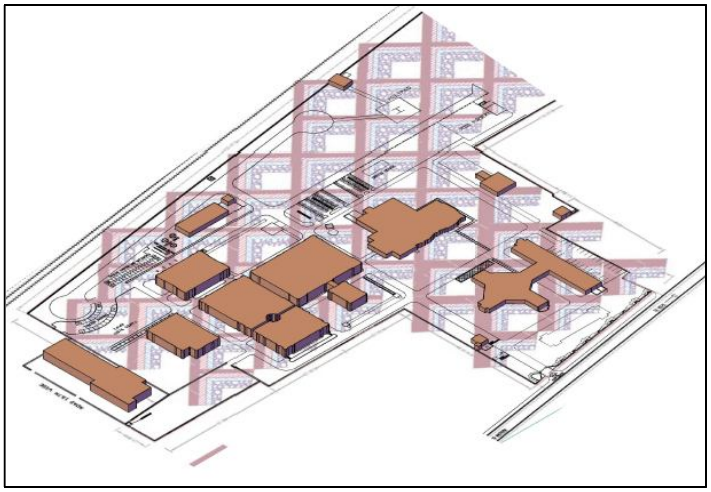

Figure 7: Fence Diagram, Source: Authors

4.9. Hydro Vulnerability Map

Based on the map interpretations three types of zones are identified which are as follows:

- High Vulnerability
- Medium Vulnerability
- Low Vulnerability

On the western side drainage, density is low & water salinity is high with low ground water resource potential making it a High Vulnerability zone. Similarly with high drainage density & low water salinity with high ground water resource potential making it Low Vulnerability zone. With medium density & medium water resource potential lying in Medium Vulnerability making it Medium vulnerability zone.

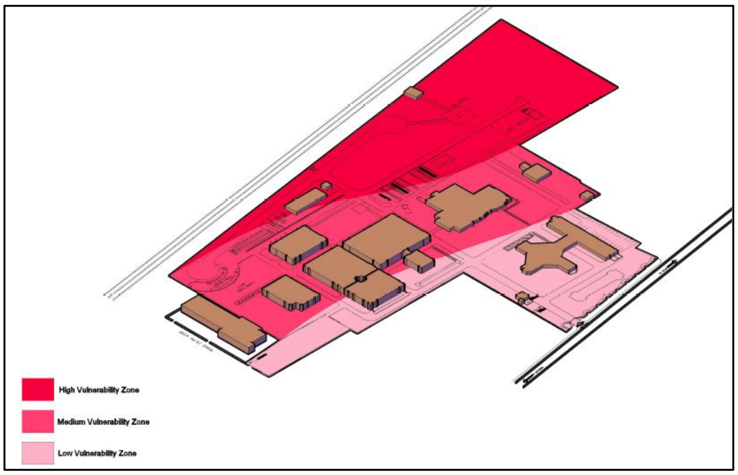

Figure 8: Hydro vulnerability map, Source: Authors

4.10. Estimation of Water Availability from Rainwater Harvesting

The Total Roof Top areas and paved areas were also calculated in order to know the rainwater potential of the area.

Rain water harvested from roof top= QRTP

Q RTP = Run off coefficient x Intensity of rainfall x area

= 0.85 X13593.7X 50/1000 = 577.73 cu metre

Assuming 70% of the water can be harvested for use, the amount of water available= 0.7x577.73= 404.41 cu metre.

Rain water harvested from road & paving = QRP

Q RP = Run off coefficient x Intensity of rainfall x area

= 0.85 X 10311.17 X 50/1000 = 438.22 cu metre

Assuming 70% of the water can be harvested for use, the amount of water available= 0.7x438.22 cu metre= 306.75 cu metre.
Rain water harvested from green areas = QGR
Q GR = Run off coefficient x Intensity of rainfall x area
= 0.30X 67306.85 X 50/1000 = 1009.60 cu metre
Assuming 40% of the water can be harvested for use, the amount of water available= 0.4x1009.6 cu metre= 403.841 cu metre.
QT = Q RTP+ Q RP+ Q GR= 1115.001 cu metre = 39.82 cu metre/day

5. Stages of Groundwater Development- A Review
SWD1 = Draft/availability x 100 = 132.5/103.96 x100= 127.45 %
As per the current scenario, the site can be categorized as a black site in keeping with the following norms as described by NABARD:
SWD < 65% - White
SWD - 65% - 85% - Grey
SWD - > 85% - Grey
Rainwater harvested from road, paving& green =39.82 cu meter/day. Addition of this quantity of rainwater harvested will yield SWD2
SWD2 = Draft/availability x 100 = 132.5/ (103.96 +39.82) x100=132.5/ (143.78) x100= 92.15 %
Addition of treated water from the treatment plant will yield SWD3
SWD3 = Draft/availability x 100 = 132.5/ (143.78 + 20) x100= 132.5/163.78 X100 = 80.90 %
Adoption of conservation measures such as use of dry land plants / Xeri-scaping plants & native species will lead to a reduction in draft & yield SWD4.
SWD4 = Draft/availability x 100 = 112.5/ (163.78) x100= 68.68 %
Adoption of conservation measures such as minimizing distribution losses will lead to enhanced efficiency and shall yield SWD5
SWD5 = Draft/availability x 100 = 112.5- 12.375/ (163.78) x100= 61.11 %
Assuming the site to be having a stage of groundwater development as 75 % as per the NABARD Norms for a grey site.
75/100= 100.125/z x 100
Z = 133.5 cu meter/day
Water available after undertaking conservation measures= 163.78 cum metre
Water available for development of hydro landscape= (163.78-133.5) = 30.28 cu metre /day

6. Conclusion & Recommendation
Having understood the critical issues of the study area some recommendations has been made. The design of the same has been stated briefly in the section that follows: In order to utilize water in an optimum and sustainable manner; it is important to not only reduce the abstraction of water but also augment and enhance the water available. This may be achieved by adopting the following: In order to reduce the water demand firstly rainwater harvesting should be adopted in the project area. Three rainwater-harvesting structures of 2.5 m radius are suggested to harvest the rainwater.

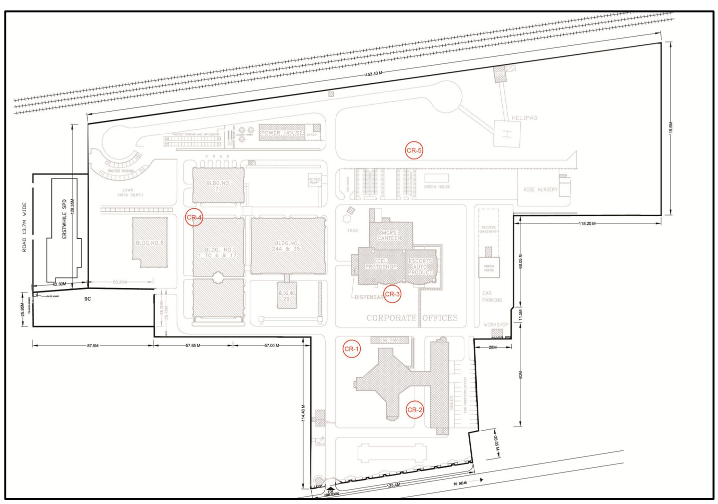

Figure 9: Location of Concentric ring system, Source: Authors

- Secondly, a root zone treatment might be applied for treating the water instead of dumping it into the municipal drain. Root Zone System uses ecological principles, which simulate the natural processes for treatment of wastewater. It is a live, self-cleaning biological filter. It removes disease organisms, nutrients, organic loads and a range of other polluting compounds. The breakdown of contaminants and the treatment of wastewater are achieved by the controlled seepage of the waterborne pollutants through a root-zone of plants. Further, it does not involve any energy expenditure. The following species of plants can be used in the root zone system:Phragmites austrails (reed), Phragmites Karka (reed), Arundo donax (Mediterranean reed), Typha latifolia (cattail), Typha augustifolia (cattail), Iris pseudacorus, Schoenopletus lacustris (bulrush).

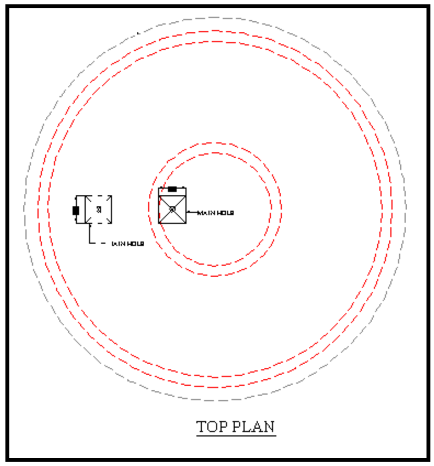

Figure 10: Top plan, Source: Authors

- Thirdly, the capacity of the existing treatment plant needs to be optimized so that availability of water for horticulture & landscape can be enhanced. This can be done by using various types of treatment such as the adoption of MBR technology (Membrane bioreactor).It is also suggested that the capacity of the treatment plant maybe fully utilized up to 35cu meter in its present capacity & the existing treatment plant may further be upgraded up to 60,000 people capacity.

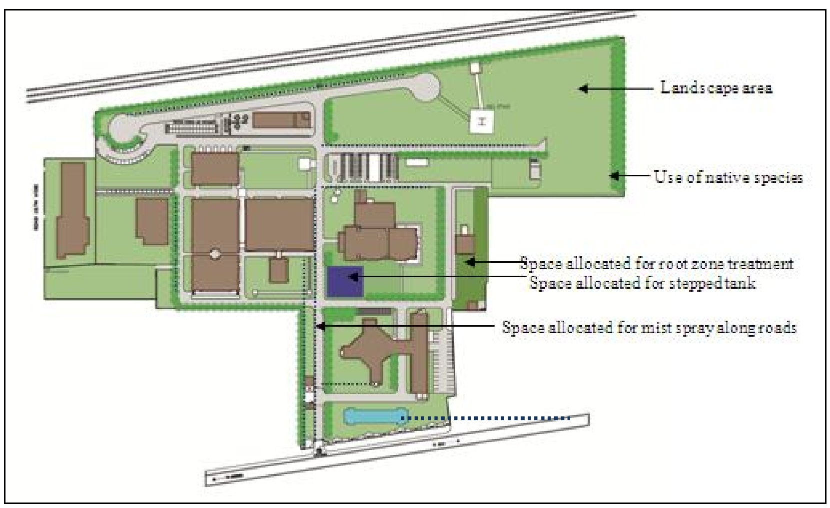

Figure 11: Conceptual Plan, Source: Authors

- The landscape irrigation demand can be greatly reduced by the application of a series of conservation techniques such as the use of dry land plants /xeriscaping plants carefully selected after hydro botanical studies. Plants with a low water requirement such as Bougainvillea, Pandanus dwarf, Caeselpinia pulcherrima, Ficusretusa, Jacaranda mimosifolia, Yucca, Asparagus sprengeri etcshould be selected.
- Native plant species should be suggested in the planting scheme in order to further reduce the water requirement. Properly-designed native landscaping can improve the value of the site, improve aesthetics, support wildlife, increase soil and water quality, and absorb noise
- The surplus amount of water obtained after various conservation and remedial measures can be utilized to enhance the thermal comfort of buildings as well as open spaces at site. Before suggesting a hydro landscape model, the site's issues need to be highlighted. Since the project, area is industrial in terms of land use, it is a victim of enhanced temperatures& thermal discomfort. This adversely affects the productivity of the workers. Therefore, the primary objective that can be achieved through the surplus water of 30.28 cu meter/day is achieving thermal comfort at site.

7. Design of Hydro landscape

Volume of water available for development of hydro landscape= 30.28 cu metre /day
Maximum amount of evaporation @ 7 mm in the month of May/June
Area x depth = volume
Area =30.28x1000/7= 4325.71 square metre.

- Water features, such as fountains or mist sprays, can be suggested along the roads while ensuring that they do not hamper circulation. These can have a significant impact on the thermal comfort; potentially improving temperatures by five deg C-seven deg C. Further, flowing water promotes air movement, which can cool a space. In addition to this it can play an important role in settling down dust particles by the installation of ESP i.e. "Electrostatic precipitators"
- Further the water being circulated in these channels can be purified by the addition of with potassium permanganate. This will impart a pinkish coloration to the water as well as purify the water.
- In order to counter low temperatures during winter's water conserved at site might be circulated in the buildings after solar heating to keep the buildings warm. Thus, passive cooling and heating might be adopted by utilizing the water conserved at site to achieve zero discharge.

8. Design of the Stepped Tank with Fountains

Volume of water available flowing to the tank= (163.78-30.28) = 133.5 cu meter
Considering the depth of the stepped tank to be 4 m & a rise of 0.8 m & tread of 0.5m, the number of steps in profile =5
Area of the tank =33.375 square metre
Assuming the tank to be a square, length& breadth of the tank = 5.77 meters
Volume of water falling from each rise of the tank= 13.90 cu meter/hr assuming the recreation time to be 10 hrs.
Area of cross section of fountain = 3.14x 0.15x0.15x0.5= 0.035 sq meter
Q= velocity x area
13.9= velocity x 0.035= 397.1cu meter /hour= 0.11 cu meter /sec.

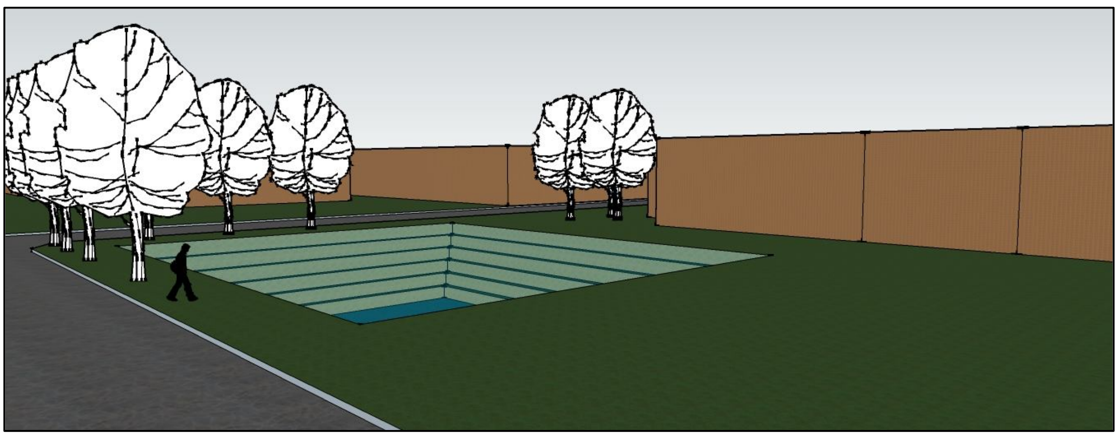

Figure 12: Conceptual Sketch of Stepped tank, Source: Authors

9. Design of Root Zone System

The term 'Root Zone' encompasses the life interactions of various species of bacteria, the roots of reed plants, soil, sun and water. Also referred to as constructed wetlands system this system helps in treating wastewater without the expenditure of energy. Plants used in the RZT conduct oxygen through their stems into their root systems and create favorable conditions for the growth of bacteria. The wastewater flow through the root zone in a horizontal or vertical way wherein the bacteria present in the rhizosphere of root plants decompose the organic pollutants biochemically. The filter media are selected carefully to provide favorable conditions for both plants & bacterial growth and to avoid clogging. Organic pollutants are removed drastically from wastewater and are reduced to their elemental forms.
Quantity of water that needs to be put through tertiary treatment of Root zone =163.78 cu metre
Area required for RZT =163.78/1.5= 109.1 sq. meters

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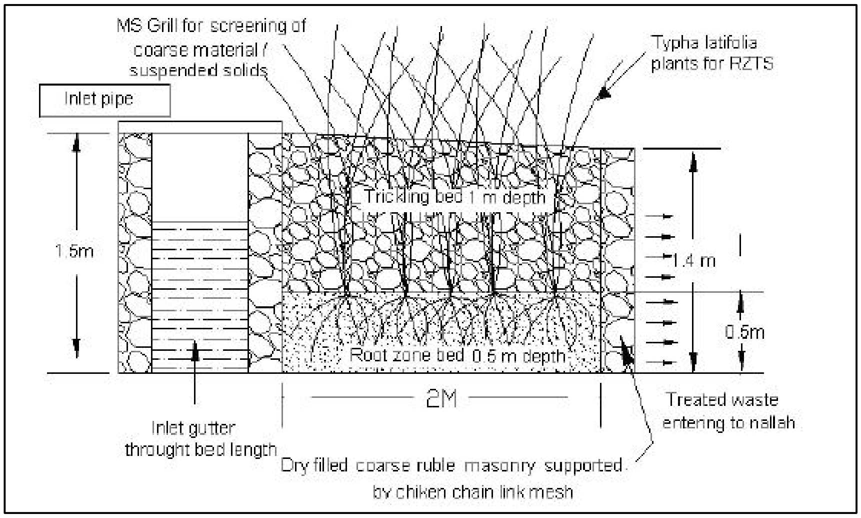

Figure 13: typical sections through proposed root zone system,
Source: Pawaskar S. R, Application of modified root zone treatment system for waste water treatment

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