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Waste Water Use in Urban Environments

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Abstract

Observers opine that humanity, after experiencing economic revolutions; agricultural, industrial, and informatics – is now on the threshold of a fourth one. This will make environmental performance and sustainability basic requisites to industrial growth and competitiveness. From now on, so the argument goes, the key word will be 'Conserve, reduce, and recycle. More and more of focus will shift to technologies on clean production processes, energy efficiency, co-generation, pollution prevention measures, advanced robotics, zero emissions from vehicles, material recycling, alternative fuels and materials. Urban Infrastructure represents a typical area of this focus. In Indian context, both existing towns and new urban dwellings/cities will experience these change. Huge investments are required to construct a sewerage system though some flexibility in their design can save on costs. A modern centralized system covering collection, evacuation or transportation and treatment of waste waters requires several inputs, field investigations, preliminary testing, criteria for designs, master planning and implementation plans. The system uses water as transportation medium.

Members of European Union, adopted a concept in 1999, called 'Integrated Product Policy' to gradually improve products and services, with respect to their environment impacts, taking into consideration their entire life span. The approach adopted covers Flux management approach that includes minimization of material flux, recovery of valuable materials and returning them into the material cycle. Water is treated as Natural good, economic and social, and is yet not recognized as a product. However to meet the quality requirements of customers, water has to be treated and purified. Waste water treatment and reclamation goes through the same linear production sequence, usage and wastage and treatment. Waste water treatment processes must, therefore, be reviewed for optimization and reduction in costs in conveyance and treatment.

The paper leads to recommendations for setting up of;

- *Sanitation Commission for Urban cities*
- *Regulators at State level for regulating efficient operations by service providers*
- *Development of Standards for all urban infrastructure engineering needs*

Introduction

The old treatment approaches relied on land and chemical treatment of waste waters. Subsequent treatment methods adopted primary settlement, biological filters and activated sludge approach. The processes for treatment have now got refined to include Nutrient removal. Among the popular decentralized methods of treatment include activated sludge, nutrient removal, Reed beds and constructed wetlands, anaerobic treatment, lagoon systems and membrane systems(for water treatment- MBR for sewage / including Kuboto system of Japan). Where concentration of water is less, including vacuum systems, high concentration of ammoniacal nitrogen in these concentrated wastes may be toxic to the nitrifiers. It is the large treatment works which attract renewed attention.It is the water resource engineers who are responsible for quality of receiving waters/ rivers that need to be consulted in their planning.

Waste water components can be divided into groups, based on composition such as microorganism,

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biodegradable organic material, nutrients, metals, other inorganic materials, thermal effects, odour and now radio-activity. The treatment processes are tailored to estimated loads of components. Indian cities with high individual income levels, and higher per capita water use, also generate a very high ratio of return water. Waste water recycling and reuse is unavoidable in such cities. While new extensions to cities can be planned, old sections of cities will need to be examined section wise. Considerable experience exists in India for community participation in rural sanitation programmes. Experience in Maharashtra has helped development of standards by community users which saved costs for benefits derived.

The socio-environments of Indian cities present considerable heterogeneity for which various options for planning and designs are available. These options include; methods of collection of wastes, specifically kitchen wastes, transportation or conveyance of waste waters and their treatment/ reuse or even mix systems of sewerage and storm waters. These options could be examined and analysed for public use by a Commission. Statutory standards can be evolved for their adoption on ground. It is well known that maintenance and operation of sewerage plants is inadequate. Regulatory framework for application and monitoring can help fill this vulnerable gap. Ministry of Urban Development, have launched JnNRUM programme for renewing planning and urban infrastructure of cities.

Planning of Water Services

Urban Infrastructure planning for water supply in large (including tier II and III cities) involves preliminaries covering:-

Mapping of urban streets, collection and conveyance of liquid waters.

Urban Infrastructure services cover roads, parking lots, street lights, water supply, waste water treatment, reuse and disposal, and storm water drainage system. The old population clusters, towns, cities and urban villages were not designed for modern vehicular traffic. Changes to facilitate faster traffic movements, by removing encroachments, improving geometrics and even taking services underground, are possible solutions. It is the road planners who will need to initiate examination of maps and decide on the levels and alignment of road pavement surface, the location and width of foot paths, the location of street lights etc. The road planners can be assisted by Engineers from other inter disciplinary services and help finalize road surface; provisions for open channels for storm water, depth and layout network of pipelines for water supplies, waste water sewers and setting of operating and maintenance system. The existing road-gradients in most cases are seldom amenable to gravity flows in storm water drains .For services which are underground, the work on roads cannot commence till sewerage system including manholes are in place. For this purpose, a city is divided into Zones, based on outfalls for storm water and sewerage system. The City planners will undertake the population growth forecasts for each of the zone /region, work out the likely futuristic water demand and carry out water supply and demand management and their analysis. Water demand is separately collated for domestic, animal needs if any, commercial, industrial, agriculture/gardening/irrigation, public use and system losses or unaccounted for water etc

An assessment of water quality to be provided and corresponding system is made in areas where augmentation of existing water supplies is visualized. The considerations in view include;

- Whether available supplies and pressures are sufficient to meet intermittent or 24x7 water demand, based on per capita norm for various clusters.
- Bulk consumers and committed supply to non domestic users.
- Operation schedules and maintenance of supplies to meet seasonal variations of demands.

Detailed consumption surveys are carried out, to verify available information and estimates and related to norms as relevant to similar city environments. Parameters like maximum day's consumption, maximum week's consumption, and an hourly rate of consumption in areas of high demand are examined. The methodology is to carry out computer analysis of the existing water supply network, undertake water and power audit for each of the zones and aim at water conservation programmes. Efficiency improvements of sub systems are examined. In respect of existing water supply services, where optimisation or reducing waste of existing water is necessary. Test metering of in-house consumption is considered. Bulk flow

meters under use are also to be checked for accuracy as provided in standards. Consumer wastage and unaccounted for water is collated and analysed to draw lessons for improvement. Minimum night flows help provide good indicators of leakage and wastage. Location of pumping station and loop system for new water supply system is conceived at this point.

Sewerage System

Where waterborne systems are envisaged, sewerage pipes are laid underground the road surface. The top of manholes has to be positioned at road surface levels and therefore the invert levels of manholes and sewers are matched accordingly. The top cover of manhole and its strength must meet requirements of road design. Access to manholes from household is also laid underground. The sewerage system is constructed a designed depths below the road surface, to ensure gravity flow. Pumping or lift stations are provided only, where unavoidable. A major concern is that leakages from sewers and the joints are leak proof to avoid leachets and pollution of ground waters. The waste water is sent to a central plant/s. A key consideration in selection for the centralized plants is 'Control' over quality standards for treatment in relation to quantity and economy in costs through scale. The cost benefits may diminish when total cost of system including infrastructure and its operation and maintenance are considered. These costs are higher than for treatment plants alone. Among other Issues to be addressed are sludge use and, nutrient removal and disposal., A Study carried out by CPCB on urban Wastes has highlighted the presence of contaminants and pollutants like nitrates and pathogens in urban wastes. In low density areas, on site treatment plant are provided to save on costs. In one of the projects in Bhutan , the estimated costs of providing infrastructure services (roads, drainage, street lighting, water supply, sanitation, electricity and solid waste management , it was found that sanitation component for full option of providing conventional onsite piped reticulation serving each individual plot, offsite trunk mains and treatment was very high .Alternative examined was to have on site septic tank and soak pit/percolation trench on each plot. This transfers the cost of sanitation from the project to ech plot owner. The drawbacks are; system relies on partly treated domestic sewage and waste water being discharged into the ground. Installing piped reticulation at a later date will pose problems. The Johkasou systems , uniquely developed in Japan are among on-site systems of interest like Septic tanks, There are two systems; for each; flush toilet waste water and other for treating domestic waste waters. Effluent water quality standards vary based on reuse.. There are separate standards for treatment of grey waters. Other available options are Small bore sewers., wherein blocks of plots are connected in shallow trenches and then providing single connection to street sewer.

Among the few well known waste water treatment options are;; in Kolkatta through Lagoon treatment and subsequent cultivation of fisheries, , sale of waste water to Madras refineries and fertilizers for industrial reuse of waste water and use of treated waste waters in power stations. of Rajghat and Inderprastha at Delhi.

Decentralised sewage treatment plants in India are still a subject matter of debates .A consensus is however emerging for their adoption in new habitats. These systems can form a core of future Sanitation programme.

Storm Water Drainage

Storm water drains, called collector drains, are designed to evacuate rainwater. The drains are generally laid along building lines. These are constructed either in open rectangular channels in brickwork, in situ concrete or in precast concrete. In metro cities these are of circular concrete pipes under the road, surface, away from sewer lines. The capacity of drains is based on rainfall frequency, intensity and estimated storm water inflows. Combined sewers and, treatment for reuse are issues of attention. .It is seen that storm water drains are also becoming carriers of waste waters from nonpoint sources of discharge of wastes. 2.4 On-site and end of pipe treatment plants

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Materials in Water mains and water distribution Systems

Types of Pipes and internationally accepted Standards

Pipe commonly used in waterworks are of the following materials

Cast or grey iron

Ductile iron (DI)

Steel

Polythelyne PE/ orhigh density polythelene (HDPE)

Polyvinyl chloride (PVC)

Glass reinforced plastic (GRP)/fibre Glass

Prestressed concrete, cylinder or noncylinder (PSC)

Reinforced Concrete Cylinder (RC)

Asbestoes Cement (AC)

In this context, it is also realized that water used for drinking , washing and cooking in domestic use is not very high if demand for cleaning, flushing, watering plants and lawns is excluded. The cost economics of centralized vs decentralized systems need to be considered during master planning exercises.

Need for Master Planning

Scheme formulation of Project goes through stages of development; Automation, flow meters, leak detection and planning for contingency are the watch words Master planning The plans whether centralized or decentralized must be cost effective and tied to arrangements with external supplies and disposal arrangements. and to internal resource provisions .Energy supplies, stand byes, water metering and revenue realisation are important to success of the scheme/s.

- Master planning for roads and parking
- Master Planning of Services for Water Supply
- Master Planning for Sewerage
- Master Planning for Drainage
- Master Planning for Solid Waste Management (independent component)
- Master planning for recycling, treatment and reclamation/reuse of waste waters and Environment Management

The Master Planning exercise is followed by Preparation of Detailed Project Report (DPRs) The inputs in the reports in most cases will spill over to outside the benefited area .Water Supply and Sewerage systems are energy intensive and a lot of pumping provisions will be unavoidable, in various use modes. Urban local Bodies which eventually take over implementation, supervision of construction, operation and maintenances of services, are to be strengthened .The implementation of master plan works are best done in PPP (Public- Private Partnership) mode, where developer examines and assumes internal responsibilities of distribution within a development lot. Government will therefore need to assume responsibility for master planning works and charge External Development charges from BOT Operators/Developers , as is being done in Gurgaon, Haryana.

The town services have both external (from outside) and internal (within city) and often an intra-neighbour-hood linkages. For example, surface and ground water supplies,, sewerage disposal/Treatment plants, drainage, connectivity of main roads/traffic management, solid waste disposal and such other services transgress boundaries of a municipal .limits of town. and may warrant intervention at state level. The master planning tool is to examine merits and economics of centralized or decentralized sanitation options.

Standards , codes of practices , norms to be adopted in master planning have to draw upon documents of BIS, CPCB and published literature. European Union and USA have published their own standards which are immensely popular for engineering applications.

Inter-linkages between Roads and Water related services of infrastructure

Geotechnical data of road is required for siting and design other infrastructure services. roads cross drainage data /bridge data is also incorporated by designers. To avoid frequent cross cutting and trenching of road for release house hold connection can be very annoying to road engineers. Cross pipes or sleeves are provided at appropriate location in consultation with road engineers. Both disciplines adopt Longitudinal section approach in their drawings. Even construction contract packages for road and storm water drainages are floated as one package. These works are undertaken, after works of other package covering water and waste waters are complete. The construction works are authorised only by both designers and project managers , when they agree and;

- Reconfirm all proposed project components
- Confirm procurement packages and bid documents, safety and construction schedule
- Confirm land acquisition requirements
- Undertake design, preparation, planning and management of community participation components
- Carry out detailed Engineering Design
- Carry out construction supervision

Prepare public consultation and awareness including programmes for training requirements for community participation in reducing water wastage

The town supplies may have both external (rom outsides) and internal (within city) and often an intra-neighbour-hood linkage. For example, surface and ground water supplies,, sewerage disposal/Treatment plants, drainage, connectivity of main roads/traffic management, solid waste disposal and such other services transgress boundaries of a town limit. All systems are planned and designed for time- slices of about 25-30 years including pumping equipment installations. Even road pavement may need refurbishment thereafter. Cleaning of sewers, drains, pavement overlays and related engineering solutions are addressed first. This valuation is followed by measures and plans for augmentation of water resource itself and the understanding of conveyance planning and designs from the new water source, and strengthening of corresponding waste disposal system, for meeting the increased load. As the rate of water supplies increase, there is corresponding increased requirement of sewerage and sullage disposal and effluent treatment capacities. Recycling and reuse of water need segregation of sullage water from sewerage for treatment and subsequent use in HVACs and toilets. For this reason, master planning of city services is considered as an unavoidable exercise. Supply of water and reuse of waste waters, and its distribution are independent but sequential activities.

BOT projects/ Public Private Partnership model for implementation

Implementation of water supply schemes, within overall master plan and its distribution is emerging as an area of interest to BOT contractors. The water is abstracted and transported over long distance, from bulk water source for distribution and to industrial units.. This has been tried in Industrial estates and is now getting extended to domestic consumption centres. The demand water for new housing complexes in metro cities are being explored by BOT entrepreneurs and developers .The BOT options in such cases are composite – both water supply and sanitation schemes. The concession periods of the licensed contractors may range to 25-30 years. The scope of services may include buying out water from external suppliers, or including joint venture arrangements with other investors for implementing long distance water transfers , and supplementing water supplies through abstraction of ground water, recycling and reuse of waste waters, storm waters, and providing horizontal pipeline network and synchronising supplies with vertical plumbing provisions in buildings.

Bulk Water supplies (from surface or ground water sources), waste water uses and recycled water, from water treatment plants, etc .available to city fall within the purview .of municipal authorities. The infrastructure include . Pumping stations and metering stations and treatment processes (WTP),sewerage treatment plants (STP), effluent treatment plants (ETP), cooling water treatment systems , consumables like softners for boilers and such like inputs. It is we[[known that water bottling plants provide for treatment processes like bottle blowing, raw water pre -treatment, ultra filteration, reverse osmosis, pH correction, disinfection and polishing. The effluent

treatment incorporates membrane bio-reacters RO plants and Nano filteration. etc. Sewerage treatment is more intensive .in nature Bio-treatment, UF-RO treatment, etc are among the variations.

Financial investment criteria with BOT implementation

In BOT(build-operate-transfer) plan, a private operator is required to buld assets, maintain for duration of concession period and later relinquish all rights.In master planning, where life cycle cost criteria is used, and selected option is approved for investments, using concept of Present worth, assuming a discount rate., The BOT projects, are evaluated on the basis of IRR concept. Project must satisfy interest rate criteria. To reduce costs, the builder or developer of residential complex must co-opt a BOT concessionaire Land must be demarcated within the complex for design of treatment plant, service reservoir and pumping plant and related facilities for collection, treatment, water recycling provisions..Following information and guidelines used in USA is of interest:

a) EPA in USA has developed a 'composite correction programme' with procedures to evaluate and correct performance. The programme consists of diagonistic approach, with provision for prescribing and implementing performance 'QualServe' assessment programme has been developed for wastewater utility industry by AWWA and WEF(Water Environment Federation).

Communication and personal relationships between owners, designers and contractors can reduce disputes and delays arising out of on surprises and lack of interpretation. The Quality issues in the changing environments can assume different dimensions. .Pressures on ground water use are increasing, the chemistry of ground water is also being modified; dissolved additives to ground water are increasing, leachets are being added to ground water in mining and industrial areas Where these activities are close to new urban developments, problems of ground water reuse can get aggravated .

b) The ASCE Manual on Quality in Construction Project is a useful reference .Quality is defined is defined as fulfillment of project responsibilities in the delivery of products and services to meet and exceed the stated requirements. The parameters are functional adequacy, completion on time and within budget at minimum, life cycle costs Operation and Maintenance upkeep must be efficient. The ISO 9000 and ISO 14000 standards apply to management system. OSHA also applies to safety during construction.