

Understanding, Choosing and Designing of the Land Slow Rate (Irrigation), Rapid Infiltration (Infiltration), Over Flow in Treatment and Disposal of Water

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Abstract – A standout amongst the savviest method for wastewater treatment is land treatment. This procedure is characterized as the application of wastewater to the land at a controlled rate in a planned and designed setting. The reason for the action is to get valuable utilization of these materials, to improve environmental quality, and to accomplish treatment and disposal objectives in a savvy way. Land treatment frameworks incorporate slow rate (SR), overland flow (OF), and rapid infiltration (RI). These frameworks require negligible exertion for task and upkeep. The tremendous increment in the generation of waste water because of rapid development of industrialization and urbanization has presented genuine risk on human and natural assets. Wastewater has turned into a noteworthy issue in urban regions particularly in developing nations. Developed nations have the ability to endure the water purification cost however developing nations don't have that limit in as much as that they arrange untreated wastewater in to the open source water bodies. The creators of the present paper accordingly centre around land treatment of wastewater which is prudent among other regular techniques which is reasonable answer for the treatment and disposal of water especially for the developing nations including India.

Keywords: Waste, Water, Treatment, Land Application, Hydraulic, Loading, Disposal, Irrigation, Infiltration, Slow Rate

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1. INTRODUCTION

Generally basic wastewater treatment advancements can be intended to give minimal effort sanitation and environmental protection while giving extra advantages from the reuse of water. These advances utilize natural aquatic and terrestrial frameworks. They are being used in various areas all through Latin America and the Caribbean.

Urban water supply and sanitation are significant fundamental requirements for the improvement of the quality of life and enhancement of productive proficiency of the general population. In urban zones, water is tapped for domestic and industrial uses from rivers, streams, wells and lakes. Practically 80% of the water provided for domestic use, turns out as wastewater. In the vast majority of the cases wastewater is let out untreated and it either sinks into the ground as a potential toxin of ground water or is released into the natural drainage framework causing pollution in downstream territories Municipal sewage might be characterized as "waste (generally liquid) beginning from a network; might be made out of domestic wastewaters and additionally industrial

releases". It is significant wellspring of water pollution in India, especially in and around vast urban focuses. In India about 78% of the urban populace approaches safe drinking water and about 38% of the urban populace approaches sanitation services.

The procedure of land treatment is the controlled application of wastewater to soil to accomplish treatment of constituents in the wastewater. Every one of the three noteworthy procedures (incorporate slow rate (SR), overland flow (OF), and rapid infiltration (RI)) utilize the natural physical, compound, and organic components inside the soil– plant– water matrix. The SR forms utilize the soil matrix for treatment after infiltration of the wastewater, the real contrast between the procedures being the rate at which the wastewater is stacked onto the site. The OF procedure utilizes the soil surface and vegetation for treatment, with constrained permeation, and the treated emanating is gathered as surface runoff at the base of the slope.

These frameworks can regularly be the most cost-effective choice regarding both development and task and are in this manner, much of the time being utilized in little communities and rural zones.

Discharge of untreated sewage in water courses both surface and ground waters are the most significant water polluting source in India. Out of around 38000 million liters for each day of sewage generated treatment limit exists for just around 12000 million liters for every day. In this way, there is an expansive hole among generation and treatment of wastewater in India. Indeed, even the treatment limit existing is additionally not adequately used because of activity and upkeep issue. Task and upkeep of existing plants and sewage pumping stations isn't agreeable, as about 39% plants are not adjusting to the general standards recommended under the Environmental (Protection) Rules for discharge into streams according to the CPCB's study report. There are 35 metropolitan urban communities (in excess of 10 Lac Population), 15,644 Million Liter for every Day (MLD) of sewage is generated from these metropolitan urban areas. The treatment limit exists for 8040 MLD i.e., 51% is treatment limit is made. There are anticipated 498 Class-I Cities (having more than 1 Lac Population). Almost 52% urban areas (260 out of 498) urban areas are situated in Andhra Pradesh, Maharashtra, Tamilnadu, Uttar Pradesh and West Bengal. The sewage generated in class-I urban areas evaluated 35558.12 MLD [1-3]. Complete Sewage treatment Capacity of class-I urban areas is accounted for 11553.68 MLD, which is 32% of the sewage generation. Out of 11553.69 MLD sewage treatment limits, 8040 MLD is treated in 35 Metropolitan urban communities for example 69%. This shows other than metropolitan urban communities, the limit of 462 Class-I urban areas is just 31%. This will in general show that just piece of the waste water is being dealt with and staying discarded with no treatment presenting risk to natural condition and human wellbeing, along these lines requires minimal effort treatment like land treatment.

2. LAND TREATMENT

Land treatment is characterized as the controlled application of waste water onto the land surface to accomplish a predefined dimension of treatment through natural physical, compound, and organic procedures inside the plant soil-water matrix. An exertion has been made in the present paper to depict land treatment of wastewater including the determination and structure of framework for land treatment having least effect on the earth and least expense of operation. Such a treatment would be pertinent where adequate land is accessible. Waste water treatment is normally comprising of regular Physical, compound, organic and mix thereof yet such treatments include high capital and repeating cost incorporating sensitivity in support and operation. In any case, Land Treatment of waste

water is similarly minimal effort and of least sophistication. Land treatment is the controlled application of waste-water to the land at rates good with the natural physical, concoction and organic procedures that happen on and in the soil. The three principle kinds of land treatment frameworks utilized are slow rate (SR), overflow (OF), and rapid infiltration (RI) frameworks. Waste water is a recyclable commodity. Natural issue as nitrogen, phosphorus, and micronutrients in waste water are commonly hurtful when discharged to lakes and streams, however these constituents have a positive monetary esteem when connected under legitimately controlled conditions to vegetated soils. In any case, the wastewater might be delegated solid, medium and weak, the subtleties of which is reflected in Table 1 underneath.



Figure 1: Wastewater: Land treatment system

The specialized plan of the land treatment framework predominantly relies upon the method of wastewater application, and qualities of wastewater and on location soil profile. The parameters that ought to be given most extreme thought amid land application are broken down salts, suspended solids, supplements like nitrogen and phosphorus, natural issue, cations like sodium and magnesium, and poisonous substances. The significant site conditions incorporate the depth of the soil mantle, depth of ground water table, slope and penetrability.

3. LAND TREATMENT METHODS

Land treatment of waste water is called as land application of wastewater or natural treatment of waste water which includes the fundamental idea utilizing vegetation spread, soil surfaces and topographical materials to expel certain pollutants. The accompanying three fundamental sorts of land treatment frameworks are utilized.

- **Slow rate**

Slow rate (SR) land treatment is the controlled application of wastewater to vegetated land surface at a rate commonly estimated as far as a couple of centimetres of liquid every week. The structure flow

way relies upon infiltration, percolation, and generally sidelong flow inside the limits of the treatment site.

Treatment happens at the soil surface and as the wastewater permeates through the plant roots oil matrix. Contingent upon the particular framework plan, some to the majority of the water might be utilized by the vegetation, some may come to the groundwater, and some might be recouped for other valuable employments. Off-site runoff of any of the connected wastewater is explicitly maintained a strategic distance from by the framework structure.

Any surface runoff is gathered and reapplied to the framework. Treatment happens as the wastewater permeates through the soil profile (Table 2). Much of the time, the permeate will enter the underlying groundwater, or it might be blocked by natural surface waters or recouped by methods for under channels or recuperation wells.

Table 1: Major Constituents of waste-waters

Major Constituents	Strong (mg/l)	Medium (mg/l)	Weak (mg/l)
Total Solids	1200	700	350
Dissolved Solids (TDS)	850	500	250
Suspended Solids	350	200	100
Nitrogen (N)	85	40	20
Phosphorous (P)	20	10	6
Chloride	100	50	30
Alkalinity (CaCO ₃)	200	100	50
Grease	150	100	50
BOD 25	300	200	100

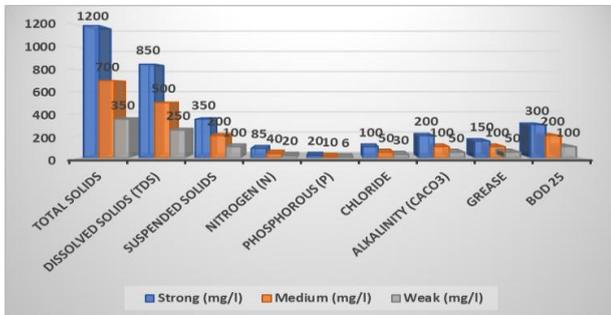


Figure 2: Major Constituents of waste-waters

Table 2: Mechanisms of waste-water constituent removal by SR systems

Parameter	Removal Mechanism
BOD	Soil adsorption and bacterial oxidation
SS	Filtration through the soil
Nitrogen	Crop uptake, denitrification, ammonia volatilization, soil storage
Phosphorus	Chemical immobilization (precipitation and adsorption), plant uptake
Metals	Soil adsorption, precipitation, ion exchange, complexation
Pathogens	Soil filtration, adsorption, desiccation, radiation, predation, exposure to other adverse environmental factors
Trace Organics	Photodecomposition, volatilization, sorption, degradation

Table 3: Removal capacity of suspended and organic matters by slow rate treatment

Parameter	Percentage Removal
BOD	90 to 99+ Percent
TSS	90 to 99+ Percent
TN	50 to 90 percent
TP	80 to 99+ Percent
Fecal Coliform	99.99+ Percent

Table 4: Applied criteria for slow rate system

Criteria CCC	Range
Field Area	56 to 560 acres/MGD
Application Rate	2 to 20 ft./yr. (0.5 to 4.0 in/wk)
Bod Loading	0.2 to 5 lb/acre/d
Soil Depth	At least 2 to 5 ft
Soil Permeability	0.06 to 2.5 in/r
Lower Temperature Limit	25 deg F
Application Method	Sprinkler or surface
Pre-treatment Required	Preliminary and secondary
Particle Size (For Sprinkler Applications)	Solid less than 1/3 sprinkler nozzle

As the essential system water is connected to agricultural lands or vegetation either by sprinkling or by surface methods, supplements contained in wastewater are used by crops and vegetation while BOD and suspended solids are expelled through water infiltration. It isn't reasonable to apply for utilization of crops. This strategy can additionally sub partition in to two classifications as Normal Rate Irrigation and High Rate Irrigation dependent on Annual Loading Rate and land necessity. Yearly Loading Rate of Normal Rate Irrigation shifts from 0.3 to 1.5 m/yr. Agricultural sites utilizing this Normal Rate Irrigation are commonly with less slope. The Annual Loading Rate of High Rate Irrigation systems are 3.0 m/yr. This rate can fluctuate as per the earth and reasonable just for permeable soil. The System is employable at evacuating hurtful wastewater constituents. Table 3 demonstrates the expulsion limit of suspended and natural issues at slow rate treatment. Table 4 indicates pertinent design criteria for Slow Rate system and land treatment system portrayed in Figure 1 underneath:

• **Rapid infiltration**

Rapid infiltration (RI) land treatment is the controlled application of wastewater to earthen bowls in permeable soils at a rate ordinarily estimated as far as meter of liquid every week. The hydraulic loading rates for RI are for the most part no less than a request of extent higher than for SR systems. Any surface vegetation that is available has a minor job for treatment attributable to the high hydraulic loadings. In any case, vegetation is at times basic for stabilization of surface soils and the upkeep of adequate infiltration rates. In these cases, water tolerant grasses are commonly used6

. Treatment in the RI procedure is practiced by natural, substance, and physical connections in the soil matrix, with the close surface layers being the most dynamic zone. The design flow way includes surface infiltration, subsurface permeation, and horizontal flow far from the application site. A cyclic application is the typical operational mode with a flooding period pursued by days or long stretches of drying. This permits high-impact reclamation of the infiltration surface and drainage of the connected percolate.

Table 5: Applicable design criteria for rapid infiltration system

Criteria	Slow Rate	Rapid Infiltration	Over Flow
Grade	< 20% on cultivated land < 40% on non-cultivated land	Not critical, excessive grades require much earth work	Finis slope 2% to 8%
Soil Permeability	Moderately slow to moderately rapid	Rapid (Sands, sandy, loams)	Slow (clay, silt and soils with impermeable barriers)
Pth to Ground Water	0.6 – 1 m (minimum)b	1 m during flood cycle, 1.5 – 3 m during dry cycle	Not critical
Climatic Restriction	Storage often needed for cold weather and during heavy precipitation	None possibly modify operation in cold weather	Storage usually needed for cold weather
Treatment Goal	Secondary or Advance water treatment	Secondary, Advance water treatment or ground water	Secondary removal
Climate Needs	Warmer seasons	None	Warmer seasons
Vegetation	Yes	No	Yes
Area (Ha)*	23-280	3-23	6-40
Hydraulic Loading (M/L)	0.5-6	6-125	3-20

The reason for a rapid infiltration system is wastewater treatment, so the system design and working criteria are developed to accomplish that objective. Be that as it may, there are a few choices as for the use or final disposal of the treated water:

- % Groundwater recharge
- % Recovery of treated water for consequent reuse or discharge
- % Recharge of adjoining surface streams
- % Seasonal stockpiling of treated water underneath the site with seasonal recovery for agriculture

The water is discharge to the land at higher rates by spreading in basing and permit to treatment of water when it moves through the soil matrix by permeation. This system is most reasonable for high permeable soil and need great natural or developed drainage. The yearly loading rate might shift from 3.0 to 150.0 m/yr. Accessibility of vegetation spread isn't a segment of this system. Toward the finish of the RI procedure BOD, suspended solids, and faecal coliforms are nearly evacuated. Table 5 demonstrates the pertinent design criteria for rapid infiltration system alongside its characteristic outline.

• **Overland flow**

Overland flow (OF) is the controlled application of wastewater to generally impermeable soils on

delicate grass covered slopes. The hydraulic loading is normally a few creeps of liquid for each week and is typically higher than for most SR systems.

Since costs will in general be legitimately identified with hydraulic loading, OF systems are normally more financially savvy than SR systems for identical water quality prerequisites. Vegetation, comprising of perpetual grasses, is a basic part in the OF system, for its commitment both to slope stability and erosion protection and to its capacity as a treatment segment.

Overland flow (OF) is a treatment procedure in which waste-water is treated as it flows down through a system of vegetated sloping terraces where waste-water is connected discontinuously to the top part of each terrace and flows down the terrace to a runoff gathering channel at the base of the slope. Application strategies incorporate high-weight sprinklers, low-weight showers, or surface techniques, for example, gated channels utilized with moderately impermeable surface soils in which infiltration through the soil is restricted rather than SR and RI systems. The emanating waste-water experiences an assortment of physical, substance and organic treatment instruments as it continues along surface runoff way. Overland flow systems can be designed for secondary treatment, advanced secondary treatment or nutrient removal, contingent upon prerequisites.

Over flow is an organic treatment process. This system is appropriate for generally impermeable soil. Body and Suspended Solids are expelled by the procedure of Biological Oxidation, Sedimentation, and Filtration. Evacuation instruments for Nitrogen (ordinarily expels 75% to 90%) are Plant take-up, Denitrification and Ammonia volatilization. Emanating is gathered in to drainage and can be reused or discharged to a surface water body.

4. PROCEDURAL DESIGN AND IMPLEMENTATION

■ **Hydraulic loading rates based on soil permeability**

Hydraulic loading rates ought to be inside estimated soil abilities. Loading is to be founded on a water balance that incorporates precipitation, evapotranspiration, and wastewater percolation. The absolute month to month loading ought to be appropriated consistently, thinking about planting, harvesting, drying and different times of no application.

The essential strides in the technique are as per the following:

- Determine the design precipitation for every month dependent on a 10-year return frequency investigation for month to month precipitation.
- Estimate the evapotranspiration rates (ET) of the chose crop for every month.
- Determine the in general saturated vertical hydraulic conductivity of the site utilizing the soil assessment.
- Establish a most extreme day by day design permeation rate that does not surpass the designed rate of the generally speaking saturated vertical hydraulic conductivity estimated at the site, contemplating recommended hydraulic loading rates dependent on soil morphology.

Calculate the month to month hydraulic loading rate utilizing the accompanying condition:

$$L_w = E_t - P + W_p \quad (1)$$

Where,

L_w = Wastewater hydraulic loading rate, inches every month.

P = Design precipitation, inches every month.

E_t = Evapotranspiration (or crop immoderate utilization of water), inches every month.

W_p = Percolating water, inches every month (utilize a level of the base saturated vertical hydraulic conductivity).

Compute the loading rates for every month with alterations for those months having times of non-application. Times of non-application might be because of wet climate, Coldwater, vegetation management or maintenance.

■ Hydraulic loading rate based on nitrogen limit

Nitrogen the board for the SRI procedure chiefly includes crop take-up with some denitrification. Oxygen consuming nitrification includes the breakdown of natural nitrogen to ammonia and ammonium. Through the activity of bacterial creatures, for example, Nitrosomonas, the ammonium particle is separated to nitrite-nitrogen. This is additionally separated through the activity of Nitrobacter microorganisms to nitrate-nitrogen. Denitrification includes the biological decrease of nitrate to nitrite lastly nitrogen gas. Such biological denitrification requires microscopic organisms (Pseudomonas, Micrococcus, Bacillus, and

Acomobacter), anoxic conditions and a wellspring of natural carbon.

The accompanying system ought to be utilized to decide wastewater loading rates when nitrogen fixation in the groundwater is a worry.

- Calculate the passable month to month hydraulic loading rate dependent on nitrogen points of confinement and month to month design flow data utilizing the accompanying condition:

$$L_n = (C_p)(P_r - E_t) + (U) (4.413)/((1-f)(C_n) - C_p) \quad (2)$$

✓ L_n = Wastewater hydraulic loading rate, in/month.

✓ C_p = Nitrogen concentration in percolating water, mg/L.

✓ P_r = Precipitation rate, in/month.

✓ E_t = Evapotranspiration rate, in/month.

✓ U = Crop nitrogen uptake, lb. /acre month.

✓ C_n = Nitrogen fixation in connected wastewater, mg/L.

✓ f = Fraction of applied nitrogen evacuated by denitrification and volatilization.

✓ Compare the estimation of the hydraulic loading rate dependent on nitrogen to the hydraulic loading rate dependent on the saturated vertical hydraulic conductivity of the soil for every long stretch of the year.

✓ After the fitting loading rate is resolved, the zone of the assimilation field can be determined.

■ Storage requirements

The capacity zone ought to be determined dependent on the base stockpiling necessity for all land treatment systems that disperse wastewater gushing onto the ground surface. Nearby climatic records just as broadly accessible climatic information, ought to be assessed to appraise the quantity of days every month wastewater won't be connected to the site because of climate conditions. Wastewater ought not be connected if any of the accompanying site conditions exist:

- ▶ Amount of snow on the ground is more prominent than one inch.
- ▶ Rainfall in the past 24-hour time span surpasses one half inch.

- ▶ Soil temperature estimated one inch underneath the soil surface is not exactly 32°F.

■ Phosphorus removal

Phosphorus is expelled from arrangement by fixation forms in the soil, for example, adsorption and substance precipitation. Expulsion efficiencies are commonly high for slow rate systems and more subject to the soil properties than on the centralization of phosphorus connected. Phosphorus retention can be improved by the utilization of crops, for example, grass with vast phosphorus take-up. Field assurance of dimensions of free oxides, calcium, aluminum, and soil pH will give data on the sort of compound response that will happen. Assurance of phosphorus ingestion limit of the soils requires research facility testing of field tests. Systems with severe phosphorus restrains in the permeate ought to incorporate observing for supplement soil phosphorus to check retention in the soil.

■ Removal of trace elements and other parameters of concern

The centralizations of trace elements and different parameters of concern fluctuate essentially, contingent upon wastewater qualities. Trace elements incorporate metals, pesticides, volatiles, and corrosive extractable and base nonpartisan organics. Trace element appraisals are important to guarantee that dimensions won't be dangerous to cover vegetation or impede groundwater quality. Sometimes, where connected groupings of trace metals are exorbitant, it might be important to keep up soil pH at 6.5 or higher.

Different constituents of concern incorporate oils, emulsions, and salts. These may stop up soils, plug nozzles, coat vegetation, be diligent or non-biodegradable/non-interchangeable with soil materials, or be harmful to vegetative cover. Emanating that displays these properties ought not be connected to the land surface.

■ Microorganism removal

The potential for public health risks from microorganism tainting because of land treatment of wastewater changes extraordinarily relying on site-explicit conditions. The variables incorporate sort of application, pre-application treatment, and community to the site, populace thickness, contiguous land use, climate, kind of on location buffer zones, and kind of vegetative cover. The assessment of these factors ought to be done to accomplish the objective of limiting general wellbeing dangers from land treatment of wastewater. All wastewater that contains pathogens must be purified before application.

5. CONCLUSION

The choice of a natural wastewater treatment system requires the thought of various components, including wastewater volume and poison qualities, site soils and topography, and climate. Land application systems likewise require a vast land region. Not all sites will be contender for land application, yet for those sites that do qualify, natural treatment will offer the proprietor and operator numerous advantages over systems that utilize mechanical and chemical treatment.

Land treatment is the most financially savvy method for wastewater treatment anyway there are some trouble in its application. Land treatment can't be utilized for vast urban areas because of its hydraulic burden impediments. In any case, it very well may be utilized in towns and little nations and wherever it's hard to utilize enormous water treatment offices. It's additionally conceivable to utilize wastewater as a wellspring of nutrition for crops however for this situation, it needs confine supervision. To defeat this limitation, it's conceivable to utilize land treatment of wastewater for non-nourishment crop which needs significantly less supervisions and confinements.

Land treatment of waste water is financially reasonable and simple to deal with. Such a treatment limits waste water to be discharged into rivers, lakes, and water bodies therefore anticipate them for being dirtied. It additionally averts ground water to dirty in the event of unpredictable discharge of waste water on land. Waste water is an asset and usable and ought not be considered as a waste and in this setting Land Application as indicated in paper can be treated as usable asset the executives. Its relevant where adequate land is accessible and water shortage exists especially in the territory of Rajasthan and other such territories. It won't have negative effect whenever prescribed hydraulic loadings on a predefined soil is connected. Its application domestic waste water is suggested alongside some industrial waste waters of effectively biodegradable in nature. Be that as it may, more research around there should be taken.

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