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Performance Analysis of Constructed Wetland to Treat Wastewater from Dairy Industry

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Abstract:
Horizontal sub-surface flow constructed wetland have been used from 30 years. The classification of constructed wetland is based on the vegetation of constructed wetland is based on the vegetation type, hydrology & subsurface flow can be further classified according to the flow direction. It is estimated that about 2% of the total milk is wasted into drains Increase in demand for milk and their products many dairies of different sizes have come up in different places. The dairy industry involves processing raw milk into products such as consumer milk, butter, cheese, yogurt, condensed milk, dried milk (milk powder), and ice cream, using processes such as chilling, pasteurization, and homogenization. The effluents are generated from milk processing through milk spillage, drippings, washing of cans, tankers bottles, utensil, and equipment's and floors. In this regard study is to treat the waste water generated from the dairy industry by constructed wetland Physico-chemical parameters of water samples of the dairy were examined to determine the quality of pollution.

Keywords: Constructed Wetlands- Dairy wastewater- Wastewater Treatment –effluent-characteristics.

I. INTRODUCTION

Ghanshyam Dairy Project: Ghanshyam dairy product is established in 1990. Ghanshyam dairy product plots no w-40. Sangli. Miraj industrial area miraj block. In this buffalo and cow milk is collected in two shifts. A 15,000lit milk is collected daily in which 11,000lit is buffalo milk and remaining 4,000lit is cow milk. It collected in the can having 40lit capacity. The milk purchased to be further processed to manufacture kind of milk, double tonned milk, full cream milk, skimmed milk, standard milk & milk products. Milk collected is depend on % fat and % SNF and is shall be free from adulterate. Daily 10,000lit dairy wastewater is generating. The milk collected is transport to Mumbai as per demand. The milk is collected and stored in hygienic condition. And daily all equipment is cleaned with the caustic and nitric acid. The milk is one of the most important commodity entering trades and it is required in everyday life as an article of food. Since the milk is highly perishable, basic public health and economic consideration is required that consumer should be provided with the product which is of good quality, pure, free from pathogenic bacteria. To maintain quality standard, quality control operation has to be performed at all the stages of production of milk which includes maintenances of sanitary conditions at milking place, storage, transportation and handling the milk at reception docks, processing and packing etc. till the milk is delivered to consumer. India ranks first among the maximum major milk producing nation. The dairy industry is one of the important food industry among all and one of the highest consumptions of water. It generates between 3.739 and 11.217 million m3 of waste per year (i.e. 1 to 3 times the volume of milk processed. And is one of the biggest producers of effluents per unit of production, in addition they generate a large volume of sludge during biological treatment. The dairy industry involves processing raw milk into products such as consumer milk, butter, cheese, yogurt, condensed milk, dried milk (milk powder), and ice cream, using processes such as chilling, pasteurization, and homogenization & residual milk (i.e. milk that remains in the pipeline, milking units, receiver and bulk tank after emptying) and the wash water that cleans them, the miscellaneous equipment, and the milk house floor. This wastewater commonly includes, cleaning chemicals (i.e. detergents, sanitizers and acid rinses) water softener recharge water, and small amounts of manure, bedding, feed, grit and dirt. It is estimated that about 2 % of the total milk processed is wasted into drains. Almost all the dairy factories are facing the problem of water treatment, disposal and utilization of the waste water. Disposal of waste water into rivers, land, fields and other aquatic bodies, without or with partial treatment, in crude tanks, will soon offer a serious problem to health and hygiene. Also Wastewater from dairies and cheese industries contain mainly organic and biodegradable materials that can disrupt aquatic and terrestrial ecosystems. Due to the high pollution load of dairy wastewater, the milk-processing industries discharging untreated partially treated wastewater cause serious environmental problems. In this regard's it is very necessary to treat the diary waste water to protect the environment and ecology. But due high cost of chemical and equipment and typical design/ arrangement, the industries are not willing/ interest to treat the waste water. Hence the importance of carrying out a whey treatment as a starting point in order to optimize a simple and economic method to treat the whole dairy effluent. Moreover, the Indian government has imposed very strict rules and regulations for the effluent discharge to protect the environment. Here some natural and affordable methods are also present like Rootzone. Constructed wetlands innovation is a built technique for refining wastewater as it goes through a characteristic procedure, which includes soil, sand, miniaturized scale life forms and vegetation. Constructed wetlands also known as root-zone system is or bio-filter reed bed system or treatment wetland system or phytotechnology or phytoremediation system. The constructed wetland treatment is the method by which the waste water is fed to the plant along its root zone there by it degrades the wastes along its intake and then the water percolates through the soil layer towards the outlet by collecting the water. The arrangements are simple.

Causes for Maximum Growth of Bacteria in Initial Stage:

1. The causes of growth rate of bacteria are lack of awareness about the cleanliness.

2. At the time of collection of raw milk there are lacks of proper hygiene condition.

3. The pots used for collection of milk are not clean.

4. Milk collected from animals which are suffering from diseases like Tuberculosis, Ranikhet which containing more number of pathogenic bacteria. So, we have to be careful about it. We should try to remove the bacteria as maximum as possible.

Remedies for the Removal of Bacteria:

1. Importance should be given for hygiene.

2. People collecting milk should use hand gloves.

3. Milk collecting pots must be properly washed and dried.

4. The collecting centres of milk must be clean and tidy.

5. Confirmation about animal health is necessary.

II. LITERATURE REVIEW

Rechard P. Reaves *et al*,. (1994) studied the performance of typha latifolia for dairy wastewater treatment. After one full year of operation it was found that significant reduction in the concentrations of BOD5 (62-81%), reactive phosphate (62-89%), Total phosphorus (49-78%), Amonia nitrogen (50-70%), TSS (65%), have been found.

Erin Smith *et al*,. (2006) studied Two small-scale constructed wetlands (100 m2) of differing operational depth (wetland 1: 0.15 m shallow zone depth and wetland 2: managed water level) were designed. Both wetlands were monitored from November 2000 through March 2002 to evaluate treatment efficiencies and mass reductions of five-day biological oxygen demand (BOD5), total suspended solids (TSS), total phosphorus (TP), and ammonia-nitrogen (NH3-N). An average loading rate of 44.7 kg BOD ha_1 d_1 was loaded into each wetland, even during winter months. Percent removal and mass reductions for BOD5, TSS, TP, and NH3-N in both wetlands, irrespective of water levels, ranged from 62 to 99%. The treatment of TP was not found to be as effective as the other parameters, especially during high loading periods Aila Carty et al,. (2008) Is comprises the scientific justification for the Farm Constructed Wetland (FCW) Design Manual for Northern Ireland and Scotland. Moreover, this document addresses an international audience interested in applying wetland systems in the wider agricultural context. Farm constructed wetlands combine farm wastewater (predominantly farmyard runoff) treatment with landscape and biodiversity enhancements, and are a specific application and class of integrated constructed wetlands (ICW), which have wider applications in the treatment of other wastewater types such as domestic sewage. The aim of this review paper is to propose guidelines highlighting the rationale for FCW, including key water quality management and regulatory issues, important physical and biochemical wetland treatment processes, assessment techniques for characterizing potential FCW sites and discharge options to water bodies. The paper discusses universal design, construction, planting, and maintenance and operation issues relevant specifically for FCW in a temperate climate, but highlights also catchment-specific requirements to protect the environment. Jan Vymazal, (2010) mentions in his first experiment using wetland macrophytes for wastewater treatment were carried out in Germany in the early 1950s. Since then, the constructed wetlands have evolved into a reliable wastewater treatment technology for various types of wastewater. The classification of constructed wetlands is based on: the vegetation type (emergent, submerged, floating leaved, free-floating); hydrology (free water surface and subsurface flow); and subsurface flow wetlands can be further classified according to the flow direction (vertical or horizontal). In order to achieve better treatment performance, namely for nitrogen, various types of constructed wetlands could be combined into hybrid systems.

S. Dipu (2011) studied to compare the efficiency of aquatic macrophytes like Typha sp., Eichhornia sp., Salvinia sp., Pistia sp., Azolla sp. and Lemna sp. to treat the effluents from dairy factory, under laboratory conditions in constructed wetlands. The biological oxygen demand and chemical oxygen demand of dairy effluent were reduced up to 65.4–83.07% and 70.4–85.3%, respectively, after treatment with constructed wetland technology.

Bharati S. Shete et al,. (2013) is discussed Dairy industries have shown tremendous growth in size and number in most countries of the world. These industries discharge wastewater which is characterized by high chemical oxygen demand, biological oxygen demand, nutrients, and organic and inorganic contents. Such wastewaters, if discharged without proper treatment, severely pollute receiving water bodies. In this article, the various recent advancements in the treatment of dairy wastewater have been discussed and stress is given on the lowest cost of the best possible treatment.

Pachpute et al,. (2014) studied the performance of Canna indica for dairy wastewater treatment. By which the pH, suspended solids, TDS, and the significant reduction in the parameters were observed and hence found more useful. In the study they found that initially the waste water sample was too alkaline but after the treatment the pH was observed near the Neutral also the TSS and TDS removal efficiency of 81% and 42% respectively was observed. The aim of study is to degrade the dairy waste in a natural environment without using chemicals and to make the water for reuse.

Pachpute A. A et al,. (2014) studied the performance of constructe wetland for shakti dairy plant located at Kashti Tal Shrigonda .The study is carried out for the one week. He observed the significant reduction in pH, BOD, COD and the parameters were observed and hence found more useful. In the study found that initially the waste water sample was too alkaline but after the treatment the pH was observed near the Neutral also the BOD and COD removal efficiency 85% and 75% of and respectively was observed.

Prof. N. B. Singh et al (2014) studied The dairy industry generate on an average 2.5- 3.0 litres of wastewater per litre of milk processed. Generally this wastewater contains large quantities of fat, casein, lactose, and inorganic salts, besides detergents, sanitizers etc. used for washing. These all contribute largely towards their high biological oxygen demand (BOD), chemical oxygen demand (COD) and oil and grease much higher than the permissible limits. pH varying between 1.0 and 13.0, further complicating the question of treatment. BOD is directly related to milk wastes (90% to 94% of the effluent BOD), and in some cases lossescan reach 2% of the volume processed by the industry.

Kavya S Kallimani et al (2015) studied constructed wetlands have gained significance for treatment of wastewater and is considered as successful optional for treatment system. The major components of the constructed wetland are vegetation type, hydraulic retention time (HRT) and bed media. In this paper we are evaluated performance of Pharagmites Austrails and Canna Indica in subsurface flow systems for removal percentage of pollutants such as Chemical oxygen demand(COD), Biochemical oxygen demand (BOD3) ,Total solids (TS) , Total suspended solids (TSS) , Total dissolved solids (TDS) and Phosphate at different Hydraulic retention time.

Objectives

- Use constructed wetland system to effectively treat the dairy Wastewater.
- Recycling and reuse of water.

prevention of further environmental degradation.

- Monitor the performance of a constructed wetland receiving dairy Wastewater.

Scope

- The constructed wetland is use to improve performance of organic matter and studies of dairy wastewater could be treated horizontal subsurface constructed wetland.
- Wastewater treated in constructed wetland can be reuse and recycle.
- It is the best option on wastewater treatment which works naturally so less expensive and more environment friendly as it does not require any chemical treatment.
- Use artificial wetland for sugar industry, pulp and paper industry to analyze the BOD, COD, phosphates, nitrates parameters.

Theory

Land areas that are wet during part or all of the year are referred as wetlands. These wetlands either natural or artificial (constructed) form, have a substantial capacity for wastewater treatment. They consist of the transitional habitats where the water table is at or near the surface of the land and includes areas that have shallow water over land, up to a depth of **2** m ***(6* ft)**. Constructed wetlands are artificial wastewater treatment systems consisting of shallow ponds or channels which have been planted with aquatic plants and which rely upon natural microbial, biological, physical and chemical process to treat wastewater and are gaining acceptance in the recent years as a viable option for the treatment of industrial effluents. The treatment systems of constructed wetlands are based on ecological systems found in natural wetlands. Constructed wetlands are different from natural wetlands in that they are designed, built and operated for human use and benefit. They are constructed in areas where a wetland did not exist before. Thus, through the designing and building, one is able to maintain significant control over the substrate, vegetation and hydraulic regime in the wetland. In controlling these parameters correctly, one is able to engineer the wetland to effectively perform wastewater treatment tasks. Additional benefits of constructed wetlands may include providing habitat for wildlife, producing an aesthetically pleasing environment, as well as modifying the local hydrology.

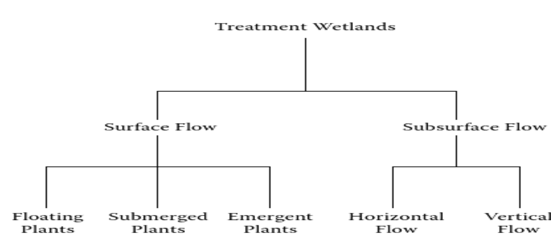
Advantages of wetland constructions

1. Constructed wetlands are relatively less expensive as compare to other treatment methods. Initial investment is low and operation and maintenance cost is low. Operation and maintenance require only intermittent, rather than continuous monitoring. More effective on low strength pollutants. Provide indirect benefits such as green space, wildlife habitats. Provide effective and reliable wastewater treatment.

Disadvantages of wetland constructions

1. More area or land is requiring for establishment.
2. Highly toxic materials can effect on wetlands activity.
3. Pretreatment is necessary for a medium and high concentrated pollutants. Frequent cleaning is necessary. Possible problems with mosquitoes and other pests.

Types of Constructed Wetlands



1. Surface flow constructed wetlands

Surface flow wetland consists of a shallow basin, soil or other medium to support the roots of vegetation, and a water control structure that maintains a shallow depth of water the water surface is above the substrate. Surface flow wetlands look much like natural marshes and can provide wildlife habitat and aesthetic benefits as well as water treatment. In surface flow wetlands, the near surface layer is aerobic while the deeper waters and substrate are usually anaerobic. Storm water wetlands and wetlands built to treat mine drainage and agricultural runoff are usually surface flow wetlands. Surface flow wetlands are sometimes called free water surface wetlands or, if they are for mine drainage, aerobic wetlands.

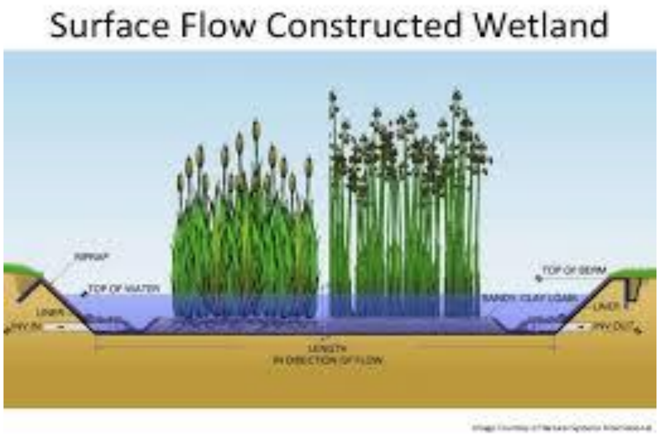


Figure. 1. Surface Flow Constructed Wetlands

2. Sub-surface flow constructed wetlands

Subsurface flow system (SSF) also known as root-zone system reed-filters/vegetated submerged bed system is a type of treatment wetland, where wastewater flows horizontally or vertically through a porous media. The workings of the SSF-CW system are vegetation, bed media, inlet and outlet arrangement and an impervious liner to prevent contamination of groundwater.

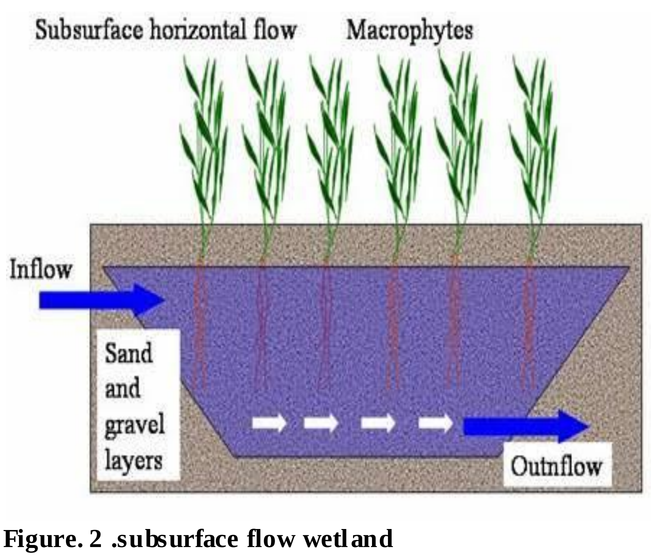


Figure. 2 .subsurface flow wetland

i. Horizontal subsurface flow system

In this system, wastewater is fed in and moves through the bed media under the surface of the bed until it achieves the outlet zone. The wastewater will come into contact with a system of high-impact, anoxic and anaerobic zones. The high-impact zones will be around the roots and rhizomes of the wetland vegetation that break oxygen into the substrate and wastewater goes through the rhizosphere, the wastewater is spotless by microbiological squalor by physical and chemical processes.

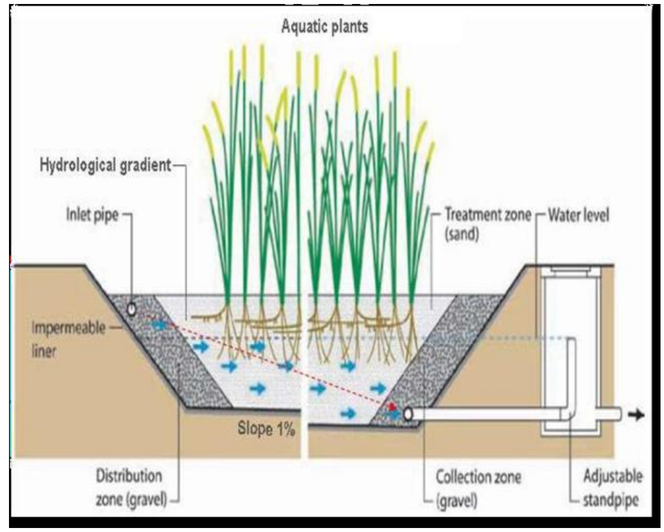


Figure .3. Horizontal Subsurface Flow System

ii. Vertical subsurface flow system

iii.

In vertical subsurface flow systems wastewater is fed intermittently and it flows in the direction of vertical through the channel funnels and it is gathered by a seepage system at the base. In 1990s, increased interest of nitrogen expulsion from wastewaters prompted more consistent utilization of vertical subsurface system built wetlands which give higher level of filtration bed oxygenation.

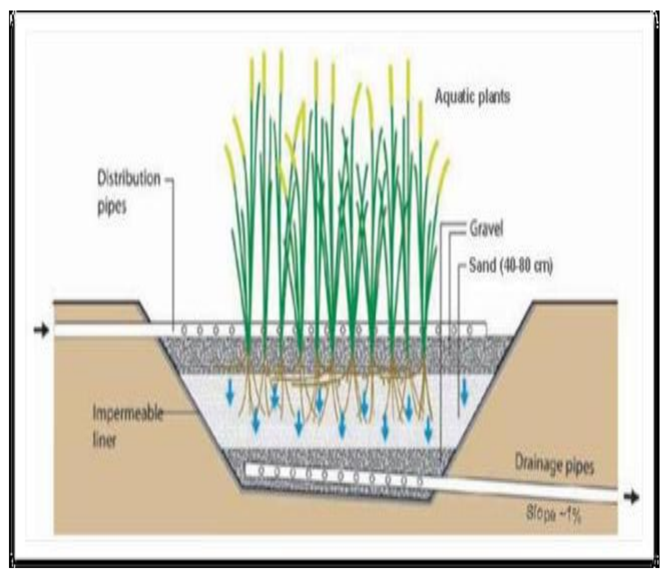


Figure. 4. Vertical Subsurface Flow System

V. Hybrid System

Constructed wetlands could be consolidated subsurface system, keeping in mind the end goal to accomplish higher treatment productivity by utilizing points of interest of individual frameworks and most crossover developed wetlands join VF and HF system. "The VF-HF system was initially composed by Seidel as in the late 1950s and the mid-1960s and in the 1980s". "VF-HF hybrid built wetlands were France and United Kingdom". At present, wetlands are more acknowledged in numerous nations.

Material and Method

Study Area:
The work is carried out at Ghanshyam Dairy Product plot no w-40. Sangli. Miraj industrial area miraj block.

pH: -
It is a term used to express the intensity of the acid or alkaline condition of a solution. It is a way of expressing the hydrogen-ion concentration or the hydrogen-ion activity. Pure water is said to be neutral, with a pH close to 7.0 at 25 °C (77 °F). Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are said to be basic or alkaline.

Chemical Oxygen Demand (COD): -

The COD test is widely used as a means of measuring the organic strength of effluents. This test allows measurement of waste of a waste in terms of the total quantity of oxygen required for oxidation to CO2 and H2O. During the determination of COD, organic matter is converted to carbon dioxide and water regardless of the biological assimilability. The dichromate reflux method is preferred over procedures using other oxidants (e.g. potassium permanganate) because of its superior oxidizing ability, applicability to a wide variety of samples and ease of manipulation. Oxidation of most organic compounds is 95-100% of the theoretical value.

Biochemical Oxygen Demand (BOD): -

The BOD is used for measuring the oxygen consumed by living organisms (mainly bacteria) while utilizing the organic matter present in waste water. It is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period. It is not a precise quantitative test, although it is widely used as an indication of the organic quality of water. It is most commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 C.

Dissolved Oxygen (DO)

Dissolved oxygen values were varying from 0.38-1.42 mg/L in waste water. The lower value of dissolved oxygen in waste water was due to higher biological and chemical oxygen demand and presence of greater quantity of organic matter in waste water.

Total Dissolved Solids (TDS): -

It is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form. Generally, the operational definition is that the solids must be small enough to survive filtration through a sieve the size of two micrometers. Total dissolved solids are normally discussed only for freshwater systems, as salinity comprises some of the ions constituting the definition of TDS. The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is not generally considered a primary pollutant (e.g. it is not deemed to be associated with health effects) it is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants.

Total Phosphate (TP)

Total phosphate value had a variation in values from 18.00-26.42 mg/L in waste water. Total phosphate value exhibited a random monthly variation in values, which could not be explained but probably was due to variation in the influx of phosphate.

Total Nitrogen

Total Nitrogen is normally reduced by denitrification, adsorption and incorporation into cell mass *(*Al-Omari, 2003*)*. Plants need Nitrogen for their growth and reproduction. They uptake nitrogen by their floating roots toincorporate it in the form of biomass *(*Baskar, 2009).

Lab analysis
1) Dissolved oxygen (DO)

The amount of oxygen freely available in water and necessary for aquatic life and oxidation of organic material dissolved oxygen.

2) pH

PH is the value expressed as the negative logarithm of hydrogen ion concentration. PH is recorded with the help of standard PH paper strips or PH-meter. It is indicating the acidity and alkalinity of water.

3) Chemical Oxygen Demand [COD]

COD test is extensively used for analysis of industrial wastes. It is pert curly useful to determine the efficiency of effluent treatment plants. COD is defined as the amount of oxygen consumed during oxidization of oxidisible matter by strong oxidizing agent such as $K_2Cr_2O_7$

4) BOD (Biochemical oxygen demand)

All ox disables organic materials, when degraded by aerobic microorganism, consume oxygen present in water the respiratory demand for oxygen by microorganism under aerobic condition is called as biochemical oxygen demand.

Table. I . Subsurface Design Aspect

Parameter	Value
Water depth (mm)	75-150 below top of medium
Porosity	0.3-0.4
Detention time (d)	3-4 (BOD), 6-10 (N)
Organic loading (Kg BOD_5/ha.d)	<112
Aspect ratio	2:1 to 4:1
Reaction Rate(d^{-1})	1.1 (BOD), 0.107 (N)
Depth of medium	0.45 – 0.75

VI. CONCLUSION:

Constructed wetland is economical compare to other conventional waste water system.so we can use this system to avoid ill effect of discharge untreated effluent on the environment.

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