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Analysis and Design of Sewage Treatment Plant using Phytorid Technology

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Abstract: The Phytorid Technology is a combination of the physical, chemical and biological processes in which resulted into ultimate treatment for the waste water. This method is more advantageous of cost effective, minimum operations and maintenance. The main objective of the project is to make green treatment system as economical as possible. It treats the sewage in natural manner using some special types of plants. The Phytorid system of wastewater management has get a lot of importance in recent times. We analyse, design, estimation and valuation of treatment plant in this project. The present analysis and design work were undertaken by our team and designed for academic building of Dr. Babasaheb Ambedkar Technological University, Lonere.

Keywords: Phytorid Technology, Sewage Treatment Plant, Phytorid bed, Phytorid-SWAB Technology, Permissible Limit

I. INTRODUCTION

Water is needed in all aspects of life and hence forms an essential part of human well-being. Nationally and internationally organizations and institutions are making efforts to provide adequate supply of potable water to everyone as it is 'Right to life' and proper handling of this resource would lead to sustainable development. But present-day conditions with increasing water demand, urbanization and improper disposal of wastewater pose harm to this process of development. The conditions in cities are worse. Therefore, policy-makers and designers must consider these challenges as opportunities and develop systems which will help in conserving the depleting freshwater resources and use water efficiently and effectively.

CSIR-NEERI has developed improved & cost effective engineered natural and sustainable treatment system for treatment of Municipal, Urban, Agricultural and Industrial Wastewater. Phytorid Technology is combination of Physical, Biological and Chemical processes, gravity based, requires minimal power. The Phytorid Technology can be constructed in series and parallel modules/cells depending on the land availability and quantity of wastewater to be treated, in subsurface flow.

II. METHODOLOGY

We visited to the Phytorid sewage treatment plant at Mumbai University, Calina campus, Santacruz west, Mumbai which is constructed and maintained by Alakananda Technologies Private Ltd. Treatment plant having capacity of 100 KLD. From this visit we study about (i) process employed (ii) initial cost of construction (iii) maintenance costs and (iv) usage of treated waste water. Following are the components of Sewage Treatment Plant using Phytorid Technology.

A. Sunk Pit

It is used to collect the water; its hydraulic retention time is 15-21 hours and suspended particles are settled here. Cleaning of sunk pit is done manually or by using suction machine and frequency of cleaning is six months.

B. Sedimentation Tank

This tank is used for settlement of colloidal particles and small size suspended particles. The retention time of sedimentation tank is 24 hours. The chemicals which are used for easy settlement is bioculture which is provided by NEERI having price Rs 7000 per liter. Cleaning of sedimentation tank is done manually or by using suction machine. Cleaning is done after every six months. We provided two stationary sedimentation tanks which works alternatively. Retention time is 24 hours.

C. Phytorid Bed

This bed consists of gravels having size 180 to 200 mm at bottom layer, 80 to 110 mm at middle layer and 25 to 30 mm for top layer. Gravels must be rough and angular in shape. Working of Phytorid bed is simply similar to continuous sedimentation tank. Vertical baffle walls are provided for reducing velocity and hence resulting in easy settlement. The depth of the tank is 2 to 2.5 m.

Water flows from top to bottom of the bed. Pipe is inserted inclined to check the level of water below the top surface of the bed. Plants, which are used are canna and syptus. As these plants survive and flourish on nutrients in sewage, they absorb oxygen from atmosphere and send down to sewage from their roots thus increasing oxygen content eventually purifying sewage in clean water. Fifteen days are required for the growth of plants after planting. Plants have fibrous roots to absorb sludge particles. Water flows under gravity by providing slope to the bed.

D. Final Storage Tank

Treated water is collected in this final storage tank. Checking of sample of treated water is done after every month. Efficiency of Phytorid technology is 90%.

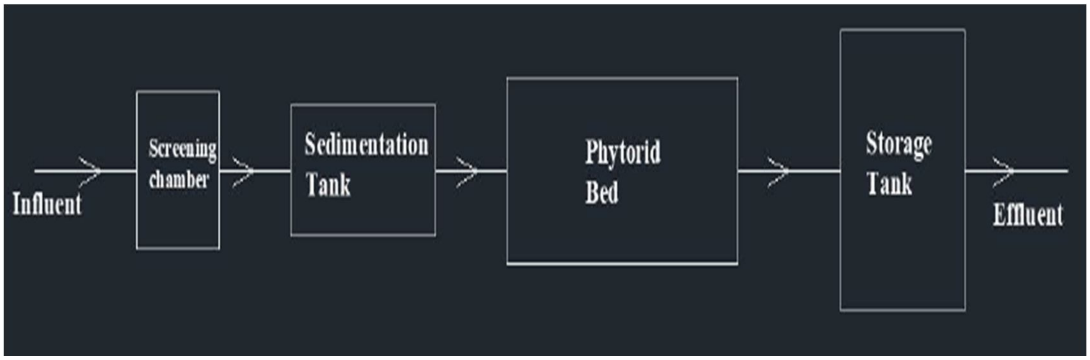


Fig 1 Flow diagram of Phytorid Treatment Plant

E. Plants used in Phytorid Bed

Commonly used plants-
Cannaindica (Indian Shot)
Colocasiaesculenta (Green Taro)
Cyperusalternifolius (Umbrella palm)
Iris Pseudacorus (Yellow Iris)
Juncusbufonius (Toad Rush)
Pennisetumpurpureum (Purple Fountain Grass)
Scirpusvalidus (Softstem Bulrush)
Strelitziareginae (Bird of Paradise)
Zantedeschiaaethiopica (Calla Lilly)
Lythrumsalicaria (Purple Loosestrife)

The most significant functions of plant species in relation to water purification are

1) The physical effects brought by the presence of the plants.
2) The plants provide a huge surface area for attachment and growth of microbes.
3) The plants remove and retain nutrients and help in preventing the eutrophication.
4) The plants assist in sediment settling and trapping process and finally increasing water transparency.

F. Performance of the Treatment Plant

The performance of the treatment plant is obtained by undergoing series of tests in different parameters and analyzing the capability of the process to change the characteristics of the water accordingly with their reaction.
Biochemical oxygen demand = 90-95%
Chemical oxygen demand = 85-95%
Total suspended solids = 90-95%
Total nitrogen = 60-85%
Phosphate = 50-80%
Turbidity = 80-90%
pH = 70-85%
Color and odor = white and no odor

G. Operation and Maintenance

The technology is natural treatment system, as the result operation is mostly passive and requires little operator intervention. Maintaining uniform flow across the treatment cells through inlet and outlet adjustment is extremely important to achieve optimum treatment performance. Sampling of inlet and outlet will be carried out for a period of 6 months for every month.

H. Permissible limits for Effluent Discharge

Table 1
Permissible limits for effluent discharge into land for irrigation

Test Name	Permissible limits for effluent discharge into land for irrigation
pH	5.5 - 9.0
TDS (Total Dissolved Solids)	500 PPM
Turbidity	30 NTU
Hardness	-
Chloride	600 PPM
Fluoride	-
DO (Dissolved Oxygen)	-
Total Alkalinity	-
Residual Chlorine	-
Odour	Aggregable
BOD	100 PPM
COD	-

III.DESIGN OF PHYTORID SEWAGE TRATMENT PLANT

A. Calculation of Sewage Quantity

Population of University = 3800

Water supply requirement for Day School (As per IS: 1172-1963 Indian Standard Code of basic requirements for Water Supply, Drainage and Sanitation). = 45 litre per capita per day

Assuming the Net Quantity of Sewage Produced as equal to 70 % of the accounted water supplied from the water works.Net Quantity of Sewage Produced = 3800 X 45 X 0.70

= 119700 litre

= 120 KLD

$= \frac{120\times10^3}{1000}$ cu .m/day

=120 cu. m /day

Average daily flow = $\frac{120}{12\times60\times60}$

$= 2.78 \times 10^{-3}\ m^3/sec$

Maximum hourly flow $= 3 \times 2.78 \times 10^{-3}\ m^3/sec$

$= 8.33 \times 10^{-3}\ m^3/sec$

B. Design of Screen

Maximum hourly flow $= 8.33 \times 10^{-3}\ m^3/sec$

Assuming that the velocity through the screens (at peak flow) is not allowed to exceed 0.8 m^3/sec

We have, the net area of screen openings required $= \frac{8.33\times10^{-3}}{0.8}$

$= 0.010\ m^2$

Using rectangular steel bars in the screens, having 1 cm width, and placed at 3cm clear spacing, we have

The gross area of the screen needed $= 0.010\times\frac{4}{3}$

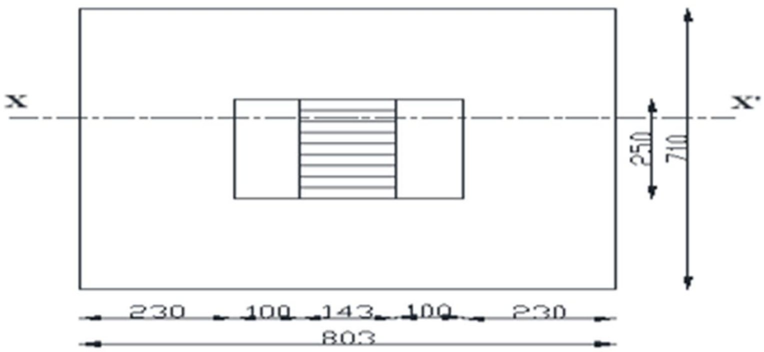
$= 0.0133\ m^2$.

Assuming that the screen bars are placed at 60° to the horizontal, we have,

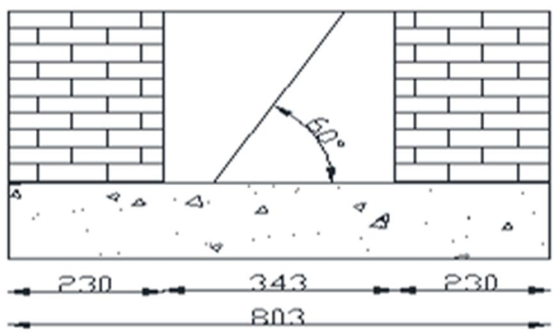
The gross area of screens needed = $\frac{0.0133}{\sin 60}$

$= \frac{0.0133 \times 2}{\sqrt{3}}$

$= 0.0154\ m^2$.



Top View



Cross Section X-X'

Fig 2 Design of screen

C. Design of Sedimentation Tank

Assuming the retention period for sedimentation tank = 24 hours

Assuming the height of sedimentation tank = 2.25

Total volume of sewage in sedimentation tank = 120 KLD = 120 m^3

Area required for sedimentation tank = $\frac{\text{volume of sewage}}{\text{height of sedimentation tank}}$

$= \frac{120}{2.25}$

$= 53.33\ m^2$.

Assuming the length to breath ratio = 3:1

53. $= 3B^2$

B = 4.22 m

L = 3B

L = 3 x 4.22

L = 12.65 m

Length of sedimentation tank ≅ 12.70 m

Breadth of sedimentation tank ≅ 4.30 m

Height of sedimentation tank ≅ 2.30 m

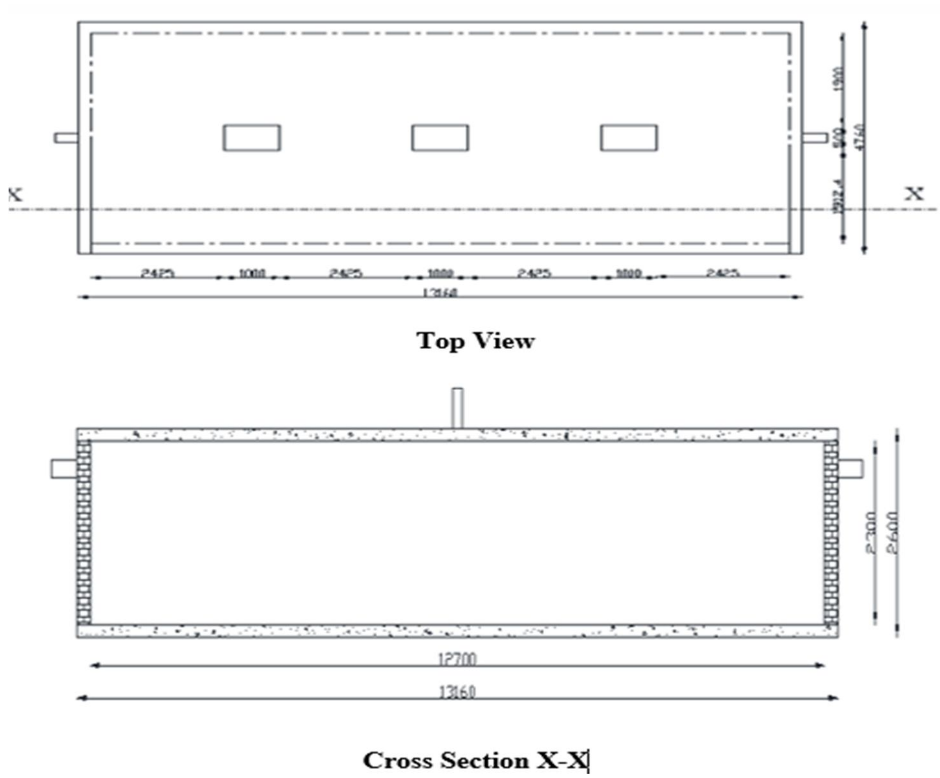


Fig 3 Design of sedimentation tank

D. *Design of Phytorid Bed*

Depth of phytorid bed = 2.4m
Length of phytorid bed =12.3m
Breadth of phytorid bed = 4.7m
Height of baffle wall =1.6m
For plant approximate $1m^2$ = 1 plant
Layers in phytorid bed,
Bottom layer =1.2m
Middle layer = 0.8m
Top layer = 0.4m

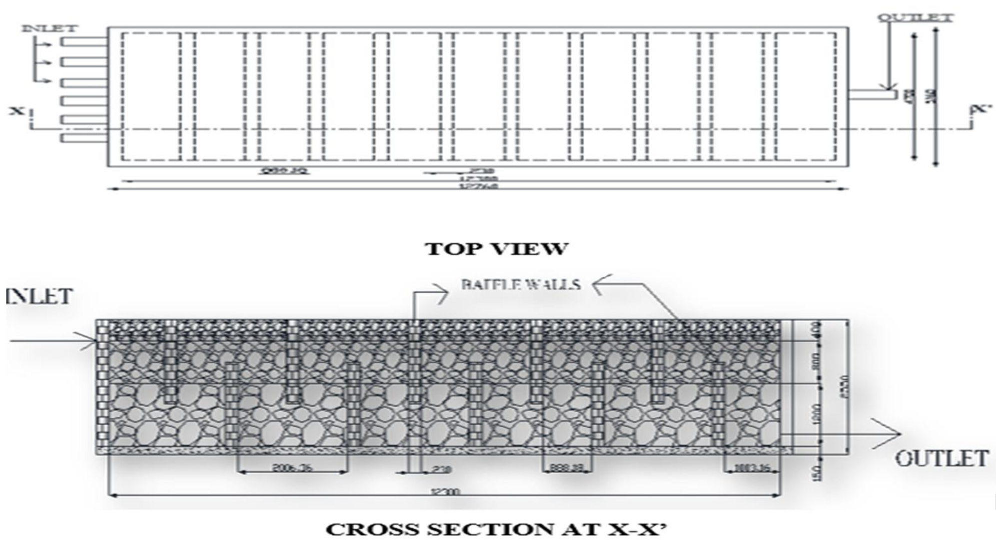


Fig 4 Design of Phytorid Bed

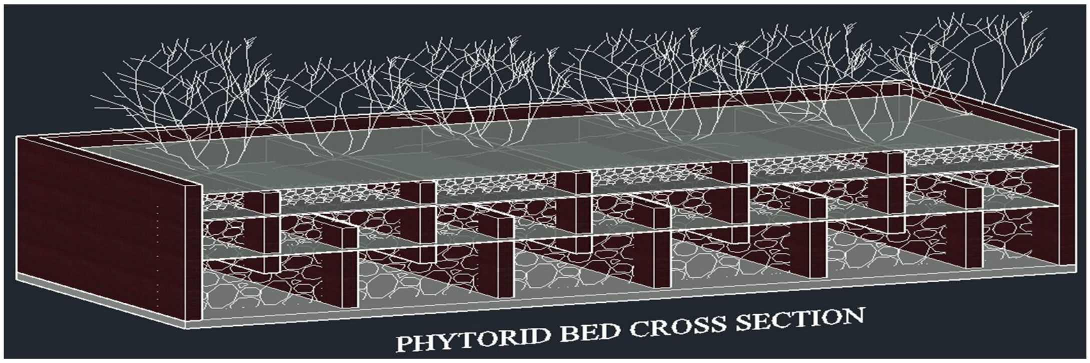


Fig 5 Typical 3D view of phytorid bed cross section

IV. RESULT

Materials required for Phytorid treatment plant

TABLE 2
Materials required for phytorid treatment plant

Sr. No.	Material	Quantity
1	Bricks	47,226 numbers
2	Cement	897 bags
3	Sand	90.254 m^3
4	Coarse Aggregates for use in concrete	107.463 m^3
5	Aggregates of size 180mm to 200mm	62.886 m^3
6	Aggregates of size 80mm to 110mm	41.924 m^3
7	Aggregates of size 25mm to 30mm	20.962 m^3
8	Stones for used in plum concrete of size 100mm	20.533 m^3
9	Steel	2855.24 kg

A. After designing of Phytorid Treatment Plant with the reference of plant where we visited, we completed total estimation of our plant. Following estimation, we completed total valuation, which is equal to Rs. 21,73,866.80 (Includes Phytorid bed, 2 sedimentation tanks, screening chamber and storage tank.)

B. The treatment results in the reduction of the BOD, COD, total suspended solids, heavy metal constituent and there is improvement in the pH level and decrease rate of the turbidity and hardness which satisfies the standards of the irrigation water needs and thereby the nutrients needed for the plant growth is obtained in the water is in specified rate that does not affect the growth and efficiency of the product. Thus, the Phytorid technology is economical, less area required, maintenance, easy construction and the energy is efficiently used with the sustainable ecology condition.

V. CONCLUSIONS

Based on the above analysis, it can be concluded that Phytorid technology is a kind of constructive wetland and a successful approach towards reuse of wastewater, which gives fair quality results. Moreover, the treated water has its application in irrigation, river dilution, gardening etc.

Some more points we concluded from above analysis which are as -

A. Land requirement for Phytorid treatment plant is less than conventional STP.

B. Maintenance cost for Phytorid treatment plant (about 1% to 2% of total construction cost of plant) is less than conventional STP.

C. If the water flows by gravity in the Phytorid treatment plant, then there is no need of electricity (hence it saves the operational cost).

D. The operation of treatment plant can be done by unskilled labours (hence no requirement of skilled labours and ultimately it saves the operational cost).

VI. ACKNOWLEDGMENT

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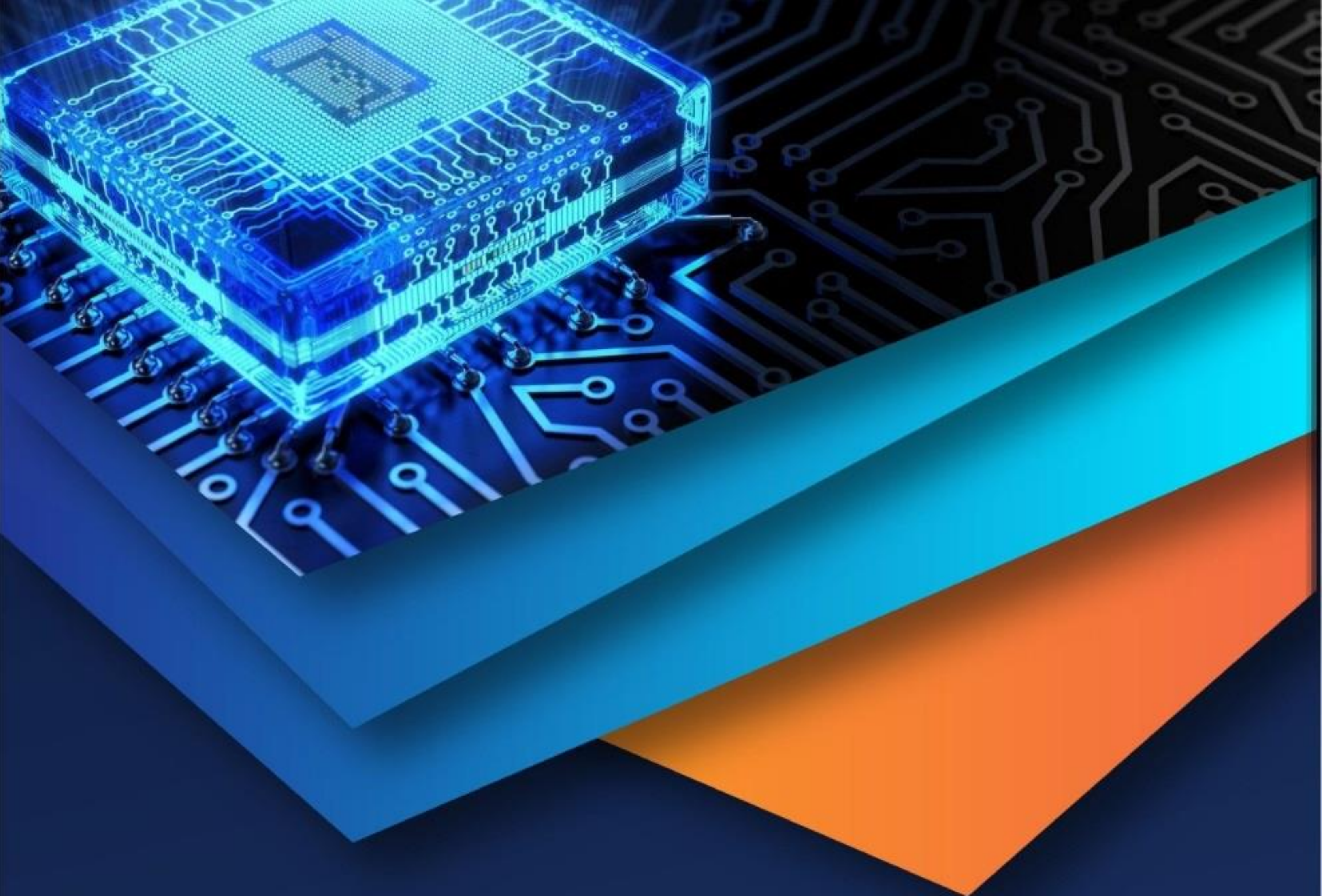

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