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"The Application of Dynamic Up – Flow Sand Filtration in Water Sludge Treatment"

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Abstract

In Egypt, Surface water treatment plants produce more than 100 million tons of sludge per year. Disposal of these massive quantities of sludge are discharged into natural water bodies. This study assessed the possibility to use the dynamic up flow sand filtration system (Dyna Sand) as a new technique successfully applied in different countries for water and wastewater from different sources in water sludge treatment.
The current study was held to evaluate and examine the efficiency of using dynamic up flow sand filter to treat water works sludge that are produced from the surface water purification in conventional water treatment plants WTPs at different operation conditions. The study was held at Elfostat water treatment plant in Dar Elsalam located in south of Cairo. The study was carried out to examine the performance of the existing conventional system in handling WTS. The samples were collected from the sludge tanks in the plant. Moreover, samples were taken after the Dyna Sand to examine and prove the success of the filter. The parameters measured to assess the filter were Turbidity, BOD, Residual Aluminum, Algae, Total Bacterial Count and Total Suspended Solids.
The filter showed high removal efficiency in eliminating these parameters. The treatment plant effluent resulted highly rates of impurities. The removal efficiency of turbidity reached 94 %, while for Total Suspended Solids 90 %. For Algae the removal efficiency was found to be 97% and for Bio chemical Oxygen Demand it was 84%. After Filtration by dynamic up flow sand filter most of these impurities were removed, thus the effluent is complying with the ministry of health requirements for raw drinking water.

Key words: Water Sludge treatment (WTS), Dynamic up flow sand filter, Waterworks Sludge, Wastewater, Bio Chemical Oxygen Demand, Residual Aluminum.

INTRODUCTION

Water treatment sludge (WTS) is produced from water treatment process of coagulation, flocculation, sedimentation and filtration. Egypt generates over 100 million ton per year of WTS and these voluminous quantities are discharged into surface water bodies, without any treatment to recycle to achieve the optimum advantage by decreasing the final disposal amounts and disposing in an environmentally acceptable and sustainable manner. **(Ann Arbor et @l, 1975)**
The rapid growth of population stands an obstacle for continuing providing potable water demand. Therefore, it requires optimum and sustainable management for current water resources under stringent environmental norms.

In general the gap remains remarkable between the population growth and the lack of water sources. Applying Innovation technologies in current water treatment plant WTPs to recycle the large quantities of water runoff in waste.

Considerable quantities of water treatment sludge WTS are generated in conventional water treatment plants due to back washing of rapid sand filters and accumulated sludge in sedimentation tanks. Reuse of water sludge treatment WTS has not been practiced in the past as a policy even in large scale water treatment plants which polluted the downstream environment. (Metcalf and Eddy, 1997)

This study is working on finding alternative solutions for reuse the water treatment sludge WTS by applying dynamic up flow sand filtration. (Nordic Water Company, 1992)

Many studies were performed on the Dyna Sand to examine its efficiency as a tool for polluted water and for tertiary treatment. O. Ali, 2013 examine the performance of an existing tertiary treatment plant, Katameya dunes, New Cairo. The study proved that the dynamic up flow sand filter is very successful and suitable in the treatment of polluted water from wastewater treatment plants.

Moreover, O.Ali and Moustafa. H, 2013 made a comparison between Rapid Sand Filter and Dyna Sand Filter in Wastewater Tertiary Treatment. The study was held in 15th of May City wastewater treatment plant. The Dynamic up flow sand filter showed high removal efficiency in the removal of the total suspended solids, while for BOD & COD the removal efficiency was similar compared to that of the Rapid sand filter. However the removal efficiency in case of Dyna Sand was steady, although in the rapid sand filter there were great fluctuations in the results, which in return will cause further problems in the case of the Rapid Sand Filter.

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Literature Review

Water works sludge is produced from water treatment plants during the treatment of surface water with large quantity wastes are generated that requires handling for disposal or reuse.

Sludge is a potential threat for the environment therefore its handling through stages of treatment including many steps with many practical and technical challenges.

Sludge Treatment is essential to meet environmental quality standards. It contains several processes such as;

- Thickening; reducing the water content and sludge volume to the minimum.
- Dewatering; increasing the dry solids content of the sludge.
- Disposal; release in safe matter.

Filtration methods are used in water and waste water treatment for the removal of particular materials found in raw water and highly effective for removing particulates of all sizes ranges including algae and colloidal clay particulates. This Study includes one of the filtration methods used in sludge treatment. **(Marcos et @l, 2017).**

Sludge Treatment

During the treatment of surface water, considerable amounts of wastewater are produced:

- Backwash water from micro-strainers.
- Sludge from sedimentation and flotation.
- Backwash water from rapid filtration.

Sludge treatment is biological/chemical wastewater treatment reduces the solved and unresolved pollutants existing in the wastewater. These are to be regained in the sewage sludge at the end of the water treatment. The sludge treatment is necessary to reduce and to ameliorate the sludge, which is produced within the raw water treatment. (lenntech)

The removal of the water content is a fundamental unit operation for the reduction of the sludge volume to be treated or disposed of. Water removal takes place in two different stages of the sludge processing phase:

- Thickening
- Dewatering

Thickening

Sludge thickening is defined as the removal of water from the sludge aiming to substantial reduction of sludge volume. For example if sludge with 0.8% dry solids (DS) can be thickened to 4% DS. The objective of thickening is to produce a sludge that is as thick as possible which can be pumped easily with relatively solid free liquid supernatant. Gravity sludge thickening is the method commonly adopted. Slope of the bottom of the gravity thickeners should be carefully selected in order to facilitate flow of thickened sludge towards the center/collection pit. Gravity thickeners are usually circular in shape and provided with pickets or rakes to improve dewatering of sludge. A dry solids content of 2-2.5% can be expected from gravity thickening. **(M. Johnson, 2009)**

Sludge thickening is a solid concentration process in which the readily separated water is removed either by sedimentation or flotation. Thickening produces a slurry or concentrated sludge and is conveniently distinguished from 'dewatering' which produces a sludge 'cake', i.e. a residue with dry solid handling characteristics. Thickening can effect a considerable volume reduction; for instance, an increase in solids concentration from 1% to 4% by a thickening process reduces the sludge volume to a quarter of its original volume. **(Bratby, 2006)**

Dewatering

Sludge consists mainly of water and dewatering is the first and most important requirement in sludge processing. The cost of treating the sludge, particularly for wastewaters, is a major component of the total cost of treatment, and the effect of the final disposal methods and return flows from sludge treatment can have significant implications for the preceding processes. **(Bruce, et@l, 1978)**

The main reasons for sludge dewatering are:

- Reduction of transportation costs to the final disposal site.
- Improvement in sludge handling conditions, since the dewatered sludge is more easily conveyed.
- Increase in the sludge heating capacity through the reduction of the water prior to incineration.
- Reduction of volume aiming landfill disposal or land application.
- Reduction of leachate production when landfill disposal is practiced.

Sludge dewatering can be done by *natural* or mechanized processes. (Robert Delatolla, 2012) Natural processes use evaporation and percolation as the main water removal mechanisms, thus requiring more time for dewatering. Although simpler and cheaper to operate, they need larger areas and volumes for installation. In contrast, the mechanized processes are based on mechanisms such as filtration, compaction, or centrifugation to accelerate dewatering, resulting in compact and sophisticated units, from an operational and maintenance point of view. (Willey- Inter science, 2006).

Drying Beds

Drying beds are one of the oldest techniques and widely used for solids liquid separation in sludge. The construction costs are generally low in comparison with mechanical dewatering options, especially for small-sized communities. The process generally has a rectangular tank with masonry or concrete walls and a concrete bottom. On the inside of the tank are the following devices to drain the water present in the sludge Part of the liquid evaporates and part percolates through the sand and support layer. The dewatered sludge stays in the layer above the sand. **(Water board)**

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The pilot unit used is installed in El Fostat Water Treatment Plant, which is located on the River Nile at Dar el Salam district in South Cairo. The influent was taken from the distribution channel between sludge tanks. The effluent is pumped to the final sludge tank. Figure 1 shows the used pilot unit of Dyna Sand, while figure 2 shows the influent pipe from sludge tank.

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Figure1: Shows Pilot Unit of Dyna Sand.

Figure2: Shows Influent Pipe from sludge tan

RESULTS AND DISCUSSION

The Experimental results for the sludge treatment showed the mentioned below results:

- ✓ Turbidity for the influent waste water was found in the range of 25 to 35 NTU, while for the effluent treated water turbidity were between 0.45 to 2.5 NTU.
- ✓ Total suspended solids for the influent waste water was found in the range of 1400 to 2600 PPM, while for the effluent waste water suspended solids were between 120 to 200 PPM.
- ✓ The Algae count of the influent waste water ranged between 10000 to 14000 unit/ml, while for the effluent waste water algae count ranged between 230 to 560 unit/ml.
- ✓ The Biological Oxygen Demand (BOD) of the influent waste water ranged between 19 to 42 mg/l, where the corresponding values of the effluent were found to be 3.2 to 5.4 mg/l.
- ✓ The Bacterial count of the influent waste water ranged between 400 to 200 unit/ml, where the corresponding values of the effluent were found to be 120 to 220 mg/l.
- ✓ The Residual Aluminum of the influent waste water ranged between 0.14 to 0.23 mg/L, where the corresponding values of the effluent were found to be 0.12 to 0.14 mg/l.

The treatment plant effluent resulted in significant improvement of the bacteriological characteristics of the influent waste water to Elfostat water treatment plant. After Filtration and Chlorination none of these organisms were found, thus the effluent is complying with the ministry of health requirements for reuse of waste water for unrestricted irrigation. The Dynamic up Flow Sand Filter can be successfully applied in the treatment of water sludge from water treatment plant; the following bar chart respectively, indicates the different parameters measured in case of water sludge treatment WTS and a comparison between the influent and the effluent of the Turbidity, Total Suspended Solids, Biological Oxygen Demand, Algae count, Total Bacterial Count and Residual Aluminum.

Table (1): shows the influent & effluent of turbidity

Sample no.	Raw Water	Filtrate	Standards	R.R %
1	30	0.45	1	98.5
2	32	2.3	1	92.8125
3	27	6	1	77.77778
4	25	2.4	1	90.4
5	31	1.3	1	95.80645
6	24	3.4	1	85.83333
7	19	1.7	1	91.05263
8	26	0.8	1	96.92308
9	25	0.7	1	97.2
10	34	1.65	1	95.14706
11	18	1.1	1	93.88889
12	36	2.5	1	93.05556
13	31	2	1	93.54839
14	29	1.2	1	95.86207
15	27	0.7	1	97.40741
16	25	0.6	1	97.6
17	30	1.3	1	95.66667
18	34	1.5	1	95.58824
19	29	0.8	1	97.24138
20	26	1.2	1	95.38462

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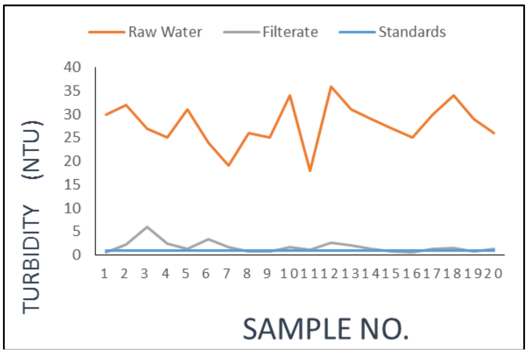


Table (2): shows the influent & effluent of Total suspended solids

Sample no.	Raw	Filtrate	R.R %
1	1648	320	80.58252
2	1782	187	89.50617
3	2620	110	95.80153
4	1445	113	92.17993
5	1765	180	89.8017
6	1560	174	88.84615
7	1700	119	93
8	2392	210	91.22074
9	947	197	79.19747
10	1344	138	89.73214
11	1612	156	90.32258
12	1892	117	93.81607

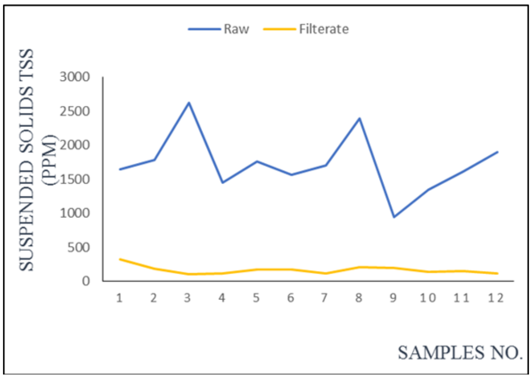


Table (3): shows the influent & effluent of Total algae count

Sample no.	Raw	Filtrate	R.R %
1	12320	560	95.45455
2	11960	440	96.32107
3	14500	570	96.06897
4	10013	314	96.86408
5	12021	230	98.08668
6	13170	260	98.02582
7	11930	310	97.40151
8	14699	298	97.97265
9	9930	265	97.33132
10	10870	300	97.24011
11	13085	406	96.89721
12	11582	386	96.66724

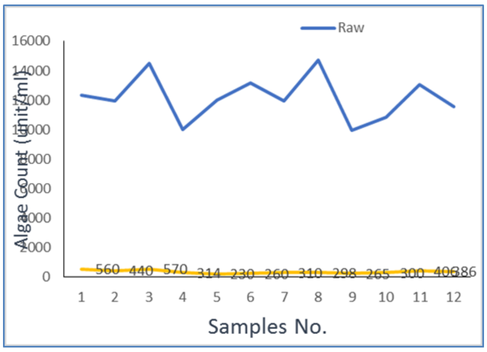


Table (4) shows the influent & effluent of Total Bacterial count

Sample no.	Raw	Filtrate	R.R%
1	200	120	40
2	260	170	34.61538
3	320	200	37.5
4	220	150	31.81818
5	200	110	45
6	400	190	52.5
7	350	180	48.57143
8	310	220	29.03226
9	230	130	43.47826
10	300	150	50
11	240	130	45.83333
12	210	120	42.85714

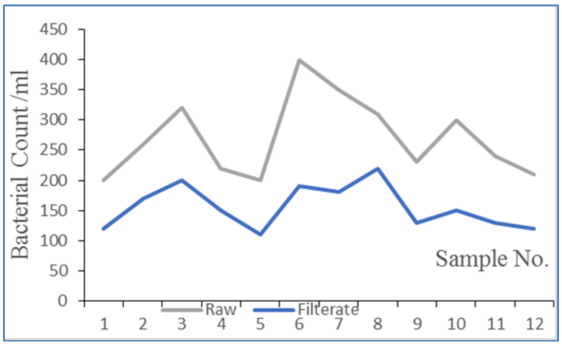


Table (5): shows the influent & effluent of BOD

Sample no.	Raw	Filterate	R.R %
1	24	4.1	82.91667
2	26	5.4	79.23077
3	30	4.2	86
4	29.4	4	86.39456
5	42	4.4	89.52381
6	28.5	5.1	82.10526
7	32	4.9	84.6875
8	42	3.9	90.71429
9	17	4.6	72.94118
10	21	3.2	84.7619
11	19	4	78.94737
12	25	4.2	83.2

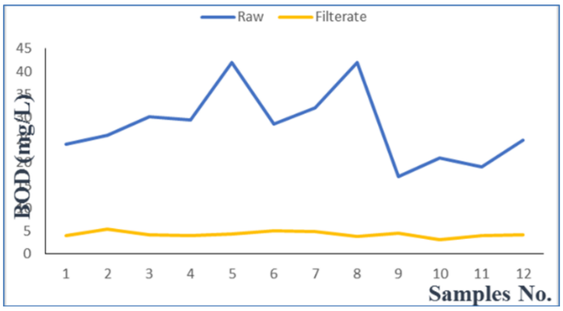
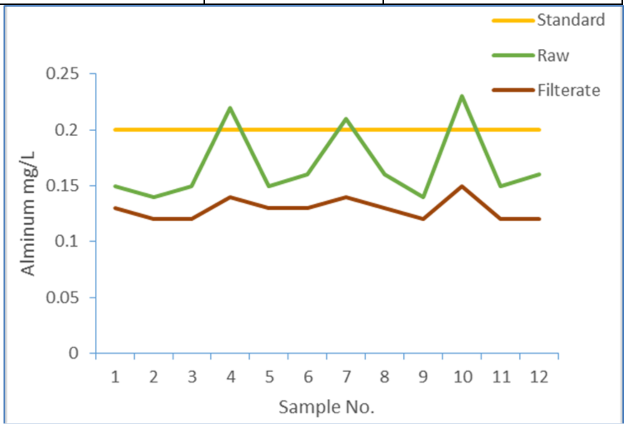


Table (6) shows the influent & effluent of Aluminum

Sample no.	Standard	Raw	Filtrate
1	0.2	0.15	0.13
2	0.2	0.14	0.12
3	0.2	0.15	0.12
4	0.2	0.22	0.14
5	0.2	0.15	0.13
6	0.2	0.16	0.13
7	0.2	0.21	0.14
8	0.2	0.16	0.13
9	0.2	0.14	0.12
10	0.2	0.23	0.15
11	0.2	0.15	0.12
12	0.2	0.16	0.12



CONCLUSION AND RECOMMENDATION

The conclusions were recorded for Water sludge treatment (WTS) as follows:
1. Significant improvement in Turbidity removal was found, the effluent treated water turbidity were between 0.45 to 2.5 NTU.
2. Drastic Drop in Total suspended solids for the effluent waste water was reached, the total suspended solids dropped from 1400 to 2600 PPM in the influent to 120 to 200 PPM in the eluent.
3. The Algae count concentration in the effluent reached 230 to 560 unit/ml.
4. The Biological Oxygen Demand (BOD) of the effluent was found 3.2 to 5.4 mg/l, after 19 to 42 mg/l for the influent.
5. The Bacterial count of the influent waste water ranged between 400 to 200 unit/ml, where the corresponding values of the effluent were found to be 120 to 220 mg/l.
6. The Residual Aluminum of the influent waste water ranged between 0.14 to 0.23 mg/L□□where the corresponding values of the effluent were found to be 0.12 to 0.14 mg/l.

The Treatment plant effluent resulted in significant improvement of the bacteriological characteristics of the influent water sludge from El Fostat Water Treatment Plant, due to the removal of part of the living organisms, the suspended solids, total bacterial count, algae, residual aluminum and turbidity.

From the results of this study, it has been proved that the Dynamic up flow sand filter is very successful and suitable tool in the treatment of polluted water from wastewater treatment plants. Therefore, it is recommended to use the dynamic up flow sand filter in:

Water sludge treatment in water treatment plants has shown improved quality of the water sludge which in return to make it applicable for recycle in water treatment plant abiding to the environmental laws.

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