

# REMOVAL OF TOTAL SUSPENDED SOLIDS AND TURBIDITY BY ACTIFLO PROCESS USING MICROSAND

Chaitra H<sup>1</sup>

<sup>1</sup>M.Tech (Environmental Engineering), Department of Civil Engineering, Bapuji Institute of Engineering and Technology, Davangere, Karnataka, India

## Abstract

Environmental issues have become serious social concerns of a global scale. Among these issues, the impact of water pollution is getting more serious. As the steel industry commits itself to sustainable development, the importance of identifying alternative methods for wastewater treatment becomes more apparent. The removal of pollutants from wastewater is an important and integral part of any industrial process. "ACTIFLO" process which is a new and developing technology. It is an alternative method for conventional clarifiers due its retention time, size, chemical consumption comparatively very less than clarifiers, nearly 20 times less than in size. Actiflo has wide range of applications: advanced treatment of secondary effluent, CSO and storm water treatment, drinking water etc; The Actiflo has many benefits like small process footprint, suited for restricted spaces and low system head loss, flexibility, short start-up time, minimum equipment maintain etc; This process has found very effective in removal of TSS and Turbidity.

**Keywords:** Actiflo, wastewater, physico-chemical treatment, microsand, weighted flocculation, lamellar settling, compact treatment unit.

-----\*\*\*-----

## 1. INTRODUCTION

As a steel industry commits itself to sustainable development, the importance of identifying alternative methods for wastewater treatment become more apparent. The removal of pollutants from wastewater is an important and integral part of any industrial process. One of method adopted in order to recycle and reuse the water is "ACTIFLO" which is the developing technology in many industries.

### 1.1 Actiflo

Actiflo is an enhanced physico-chemical suited for difficult water. It is found effectively in CSO treatment, drinking water and wastewater treatment. It can effectively remove colloidal suspended solids, organic materials and suspended particles. This process is developed by combining chemical precipitation and lamella settling with a new technique involving the incorporation of micro-sand into flocs.

### 1.2 Benefits

1. Efficiency of treatment is high ie turbidity removal exceeding 99%
2. Reduction in energy consumption
3. Reduction in retention time
4. Very small footprint
5. Reduction of total organic carbon
6. Quick startup within few minutes
7. High rise rate up to 120m<sup>3</sup>/hr
8. Usage of coagulant and flocculent is minimized
9. Sludge can be easily thickened and dewatered
10. Reduces civil cost

11. Easy to access
12. Minimum equipment maintenance
13. Stability and flexibility
14. Automized operation

### 1.3 Applications

1. The Actiflo process is ideally suited for the treatment of industrial process water, wastewater, storm water, surface and ground water.
2. Drinking water for the removal of natural organic matters, pesticides etc;
3. Reuse of water for tertiary treatment and polishing of effluent.
4. It is used in the recovery and recycle of filter backwash waste to reduce water losses.
5. It can be used in all municipal wastewater treatment applications.
6. Widely applied for combined sewer overflow and storm water treatment.
7. Direct treatment of rivers and lakes.

### 1.4 Comparison Of Actiflo With Conventional Clarifier

The Actiflo has many advantages compared to the conventional clarifier:

1. Mainly Actiflo setup footprint is very small and compact when compared to conventional clarifier.
2. The design results in footprints that are 20times smaller than conventional clarification system.

- The consumption of chemicals like coagulant and flocculent is comparatively very less than conventional clarifiers.
- Civil cost is less compared to conventional clarifier.
- This technology uses micro-sand where the ballasted flocs are formed for easy removal of pollutants which is not added in the conventional clarifier.
- The Actiflo has overflow rates from 35-60gpm/ft<sup>2</sup> with total retention time ranging from 5-12mins whereas the overflow rate of 0.5-1gpm/ft<sup>2</sup> with total retention time ranging from 2-4 hours.
- This system has much flexibility compared to conventional clarifier.
- Quick start up when compared to conventional system
- This process can give better performance for difficult waters when compared to conventional clarifier.

## 2. ACTIFLO SYSTEM PRINCIPLE

### 2.1 Process and Principle

ACTIFLO is based on combining chemical precipitation and lamella settling with a new technique involving the inclusion of micro-sand into flocs. Influent enters the Actiflo system with a chemical coagulant such as alum, ferric chloride etc; added in-line to destabilize suspended solids and colloidal matter in the influent, in this hydraulic retention time is approximately 2 minutes. The coagulated water passes into injection/flocculation/maturation tank where flocculent aid polymer and micro-sand are added to initiate floc formation. Micro-sand serves as a "seed" for floc formation and development in the next process, where it acquires weight and volume. Hydraulic retention time is approximately 4-6 minutes. The fully formed ballasted flocs is moved to settling tank, where inclined lamella plate settlers depending on the application which provides rapid and efficient removal of the micro-sand/sludge floc. Clarified water exists in the Actiflo system through a series of collection troughs.

The micro-sand flocs settle to the bottom of the clarifier and moved to the center of unit where the sludge scraper removes the sludge. The micro-sand sludge mixture is then pumped to the hydro-cyclone for separation. Pumping energy is converted into centrifugal forces within the body of hydro-cyclone causing sludge to be separated from the higher density micro-sand. Once separated the micro-sand is recovered and discharged from the bottom of hydro-cyclone and re-injected into the Actiflo process for reuse. The lighter density sludge is discharged from the top of the hydro-cyclone and sent to final disposal.

### 2.2 Theory of Operating Principle

Actiflo process is very similar to conventional water treatment technology. Both processes use coagulant for destabilization and polymer flocculent for the aggregation of suspended materials. These materials are then removed by settling for disposal. The advanced technology ACTIFLO process is the addition of micro-sand as a "seed" and forms ballast flocs.

With these considerations, the physiochemical processes involved in conventional water treatment is advantage in developing and comparison with the Actiflo process.

Conventional clarifier processes involve the destabilization, flocculation and subsequent removal of suspended solids. The flocs formed are weak and not easily removed by gravity settling. The suspended material may range in the size from 0.001 to 1 micron. The stability of colloidal suspended materials of negative charge and causes repulsion of each individual particles and remain in suspension. To counteract repulsion, a chemical coagulant such as alum( $\text{Al}_2(\text{SO}_4)_3$ ), ferric chloride( $\text{FeCl}_3$ ), ferric sulfate( $\text{Fe}_2(\text{SO}_4)_3$ ), PAC, lime are added to reduce the repulsive forces between the suspended materials. This results in the destabilization and attraction of suspended solids to form a floc. As the floc formed is of low mass cannot settle and cannot be removed due to its low settling velocity. Removal of these particles needs addition of flocculent polymer which is a bridging agent. This produces a large, settable floc with a higher settling velocity, which can be removed with gravity separation techniques. But this Actiflo process uses micro-sand which differs from conventional clarifiers.

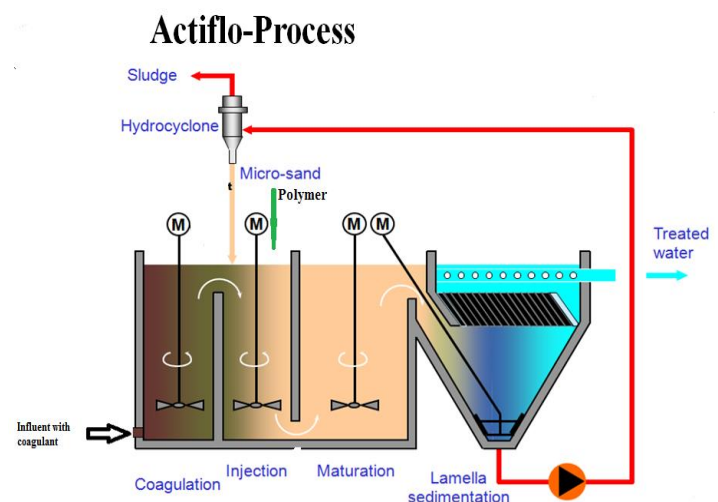


Fig 1: ACTIFLO PROCESS

### Actiflo –the principle

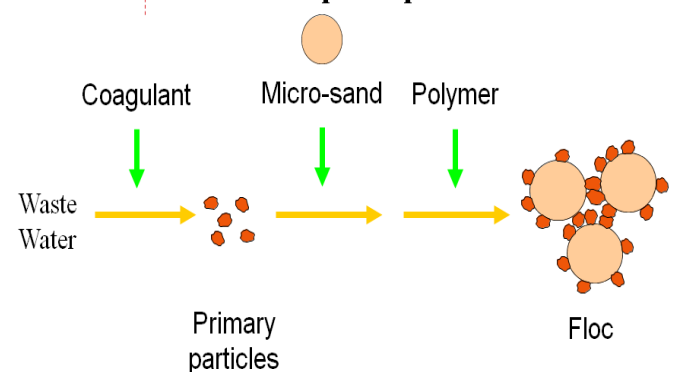


Fig 2: ACTIFLO PRINCIPLE

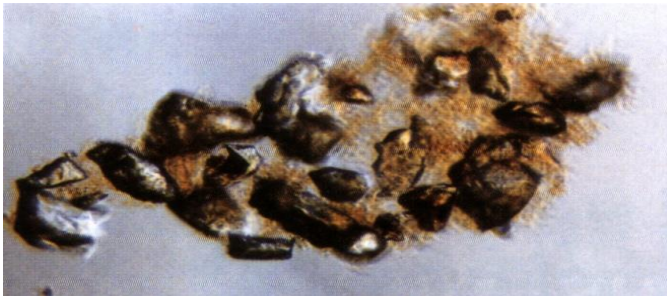


Fig 3: ACTIFLO FLOC

### 2.3 Micro-Sand

It is a media used in Actiflo process for the formation of ballasted flocs. An aggregate, which is free from clay and shale.

Its physical and chemical properties:

- Size of micro-sand is 100-150microns
- It is in solid powder form
- Its color varies from light buff to white granular solid
- The specific gravity is 2.65
- The bulk density is 38lbs/ft<sup>3</sup>
- Very stable
- Mainly it is not chemically reactive
- It is insoluble in water
- The uniformity of co-efficient is 1.5 and it is composed of 98% pure silica.(Uniformity co-efficient should 4 or less than 4 is recommended)

The micro-sand serves important role in the Actiflo process:

1. The ratio of high specific surface area to volume of the micro-sand particles serves as a “seed” for floc formation.
2. The micro-sand and polymer stimulates the involvement of suspended materials and result in the formation of large stable floc.
3. As the micro-sand specific gravity is 2.65 serves as ballast for the formation of large stable floc.
4. The high micro-sand concentration within Actiflo process effectively dampens the effect of changes in the raw water quality.
5. The chemical inert micro-sand does not react with the process chemistry, allowing it to be effectively removed from chemical sludge and reused in the process.

The use of mirco-sand results in the developing of heavy floc that is denser more than the floc formed by conventional process. This floc has high settling velocity so high clarifier overflow rates are achieved.

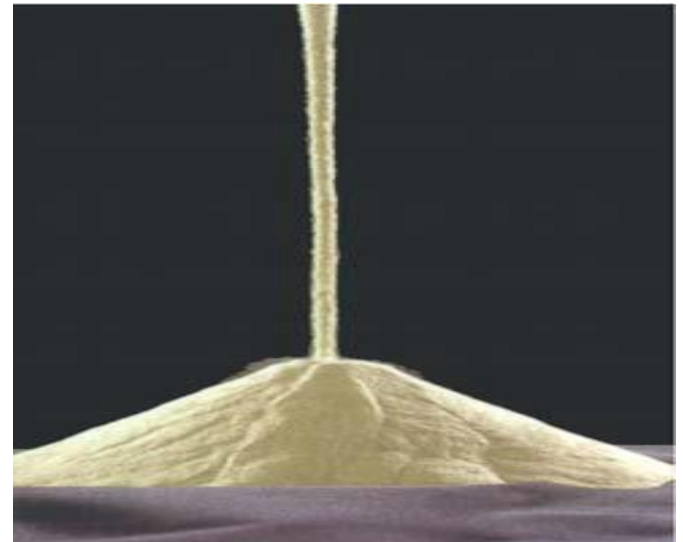


Fig 4: MICROSAND

### 2.4 Hydro-Cyclone and its Mechanism

As Actiflo process has one recycling unit known has Hydro-cyclone which helps to reuse the micro-sand by clarifying from sludge.

- A Hydro-cyclone is a static device to classify, separate or sort particles that applies centrifugal force to a flowing liquid mixture so as to stimulate the heavy and light components.
- It helps in clarifying liquids, concentrating solids, separating two solids according to their density.
- They cost less to install, operate and maintain.
- This has two exists on the axis: one at the bottom and one at the top.
- It is of cylindrical in shape, installed vertically, with large diameter upper cylinder tapering down to a narrow cylindrical section.
- Slurry enters at the top, which causes slurry to form vortex where the centrifugal forces are counteracted and without disrupting the reverse flow of separated particles in the core.
- This centrifugal force causes the denser particles to be separated from lighter particles.

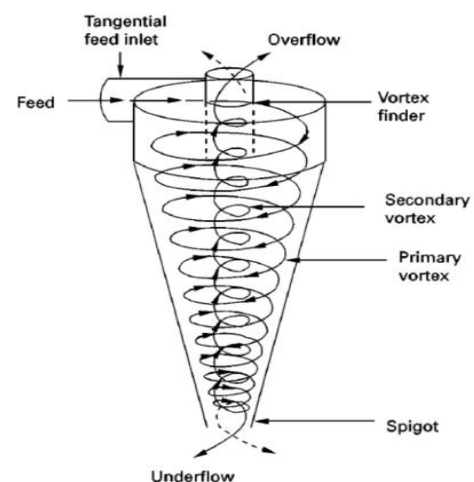


Fig 4: HYDROCYCLONE MECHANISM



Fig 5: HYDROCYCLONE

## 2.5 Applications of Hydro-Cyclone

1. In oil and chemical industries for the recovery of catalyst
2. Separating sand from sugarcane juice
3. Clarifying seed oil
4. Removing of ungrounded particles and impurities from chalk
5. Recovering of filters
6. In the removal of silt from well water
7. Cleaning of wash water from scrubbers for recycling
8. Used in nuclear power industry for the separation of corrosion products in circulation system
9. Purifying operation to clean water from sand
10. In the pre-cleaning of primary sewage sludge

## 2.6 Lamella Plate Settling

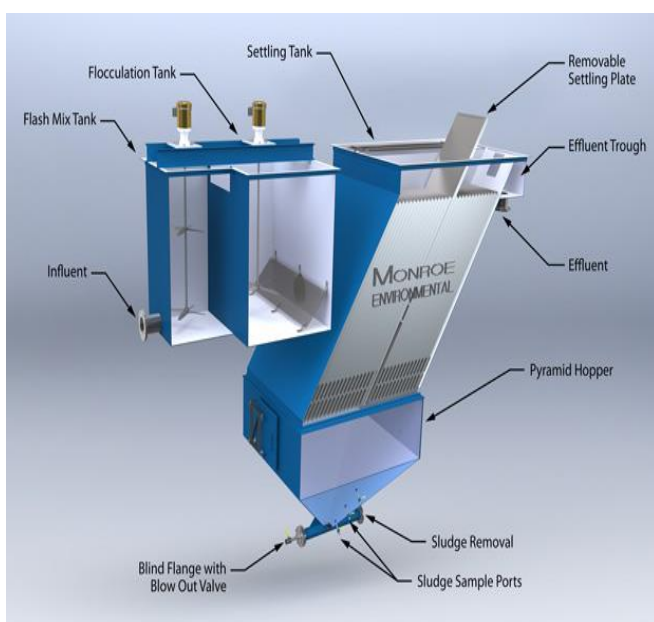


Fig 6: LAMELLA PLATE SETTLING

1. It consists of series of flat plates closely spaced at an angle between  $45^\circ$  to  $60^\circ$
2. As the water flows between the plates, the heavy solids with high specific gravity than the clarified water will settle to the bottom of plate and slides down to the sludge hopper.
3. This settler which is adopted in the Actiflo helps the process to produce the clarified water with more % removal of TSS and Turbidity

## 2.7 Material of Construction

The material of construction for Actiflo system is Mild steel. Whole body is made up of mild steel as it is easy to maintain and operate, mainly very compact. As this system is very compact, it is directly installed in the field from manufactured factory.

## 2.8 Equipments Required

1. Pump
2. Feed pumps
3. Slurry pumps
4. Recirculation pumps
5. Dosing tanks and pumps
6. Agitators
7. Scarpers
8. Lamella plates
9. Troughs
10. Mixing control device
11. Hydro-cyclone
12. Micro-sand dropping equipment
13. Valves to control

## 2.9 About the Effluent

The effluent which is sent to Actiflo system is which contains more turbidity and total suspended solids (TSS). As the molten iron is carried in ladle and is transferred to convertor, while transferring there is liberation of gaseous matter which is sucked by the ID fan where the blades of the fan gets settles by these pollutants. To clean the blades of fan water is used. Hence the water gets mixed with the pollutants resulting in the presence of high amount of TSS and turbidity. As there is water scarcity this effluent has to be recovered and reused for same purpose. In order to recover and reuse the water again to wash, the TSS and turbidity has to be removed efficiently

## 3. TESTS

### 3.1 Jar Test

Jar test is very important to analyze and calculate the amount of coagulant and flocculent dosage has to be done for the actual process. This process stimulates the coagulation and flocculation process and also helps to know whether optimum dosage is added or no to get desired effluent. Procedure conducted:

1. Take 4 jars of 1000ml volume. Add 500ml of effluent to all 4 jars.



2. As there were no fine particles in the effluent, the usage of coagulant was not found effective and didn't find any result.
3. The flocculent poly was added at a dosage of 1, 1.5, 2, 2.5ppm.
4. The filled jars on the stirrer with the paddles in each beaker.
5. The mixing speed was 100 rpm for until the particles get settle down, time was noted it was around 6 minutes.
6. After flocculation, turned off the mixer and allowed the flocs to settle.
7. The clear water which was found at 1.5ppm and 2 ppm was taken and carried out pH, turbidity and conductivity.
8. The dosage of 1.5ppm was found effective in the removal of turbidity and TSS.
9. Proposed dosage of chemicals as per jar test is 1.5ppm polymer for optimum result.

**3.2 Jar Test Results**

**Table -1: Jar test results**

	sample	Jar 1	Jar2	Jar3	Jar4
Turbidity	>1000	37	15	12.5	19.5
pH	7.64	7.5	7.8	7.9	7.8
Conductivity ms/cm	1119	996	984	990	987
Chemicals Polymer		1 ppm	1.5 ppm	2 ppm	2.5 ppm

- The best result were seen with dosage of 1.5ppm
- The NTU is 15 for 1.5ppm although turbidity is 12.5NTU for 2ppm but 1.5ppm dosed sample appears clear.
- Proposed dose of chemicals as per jar test is 1.5ppm polymer for optimum result.
- As the discharge is 50m<sup>3</sup>/hr, required polymer is 1.5gm/m<sup>3</sup>\*50m<sup>3</sup>/hr= 75gm/hr.



**Fig 6: JAR TEST**



**Fig 7: SUPERNATANTS COLLECTED FROM RESPECTIVE BEAKERS**

**3.3 Operating Conditions**

1. ACTIFLO system is an automatized in operating.
2. Mainly the hydraulic retention time is 5-12minutes.
3. The plant capacity is 16m<sup>3</sup>/hr.
4. The pump input flow is 6.5m<sup>3</sup>/hr and is adjustable by variator.
5. It is composed of 3 tanks: coagulation, flocculation and sedimentation tank with 3 pyramidal pits
6. The settled micro-sand and sludge is carried out by electro valves which is at the bottom
7. A hydro-cyclone is used to recycle and reuse the micro-sand by the mixture of sludge and sand
8. In all tanks, the mixing is done by the agitators

Parameters	Values
Upflow velocity	Upto 140m/hr
HRT	5-12mins
Coagulant	-
Flocculent	75gm/hr
Recycled micro-sand	About 2.5kg/m <sup>3</sup>

15 days analysis has been conducted to know the % removal of Total suspended solids and Turbidity. The average of influent parameters is shown in the following table:

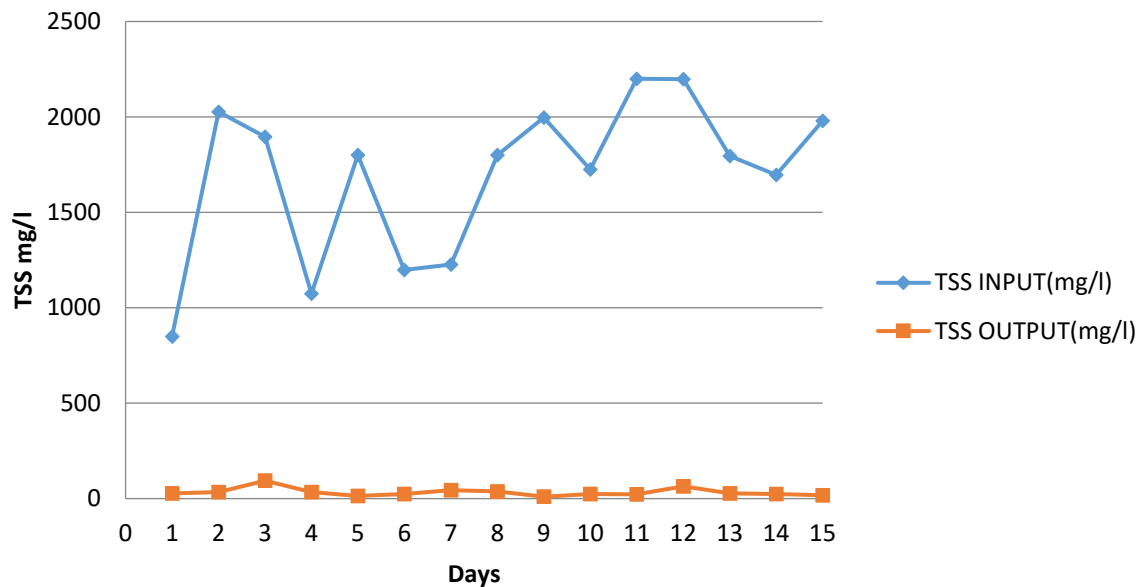
**Table -2: Average Influent parameters**

SL.NO	PARAMETERS	UNITS	ID FAN WATER QUALITY AVERAGE
1	pH	Unitless	7-9
2	Turbidity	NTU	1200-2200
3	TSS	ppm	1200-2200
4	TDS	ppm	400-600

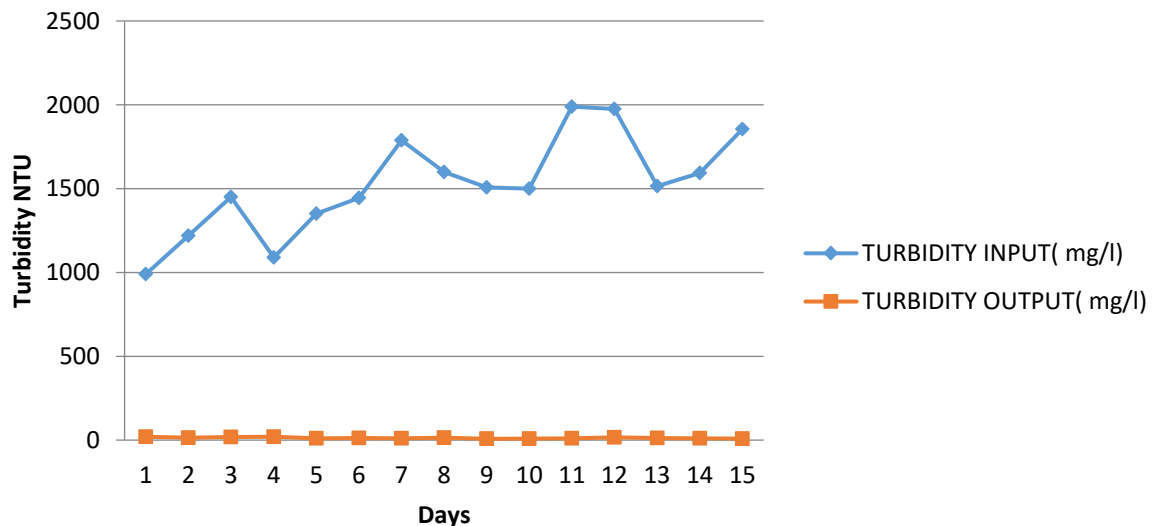
The average of Effluent parameters is shown in the following table:

**Table -2:** Average Effluent parameters

SL.NO	PARAMETERS	UNITS	ID FAN WATER QUALITY AVERAGE
1	pH	Unitless	7-8.5
2	Turbidity	NTU	8-20
3	TSS	ppm	10-95
4	TDS	ppm	400-500



**Chart -1:** TSS INPUT AND OUTPUT REMOVAL

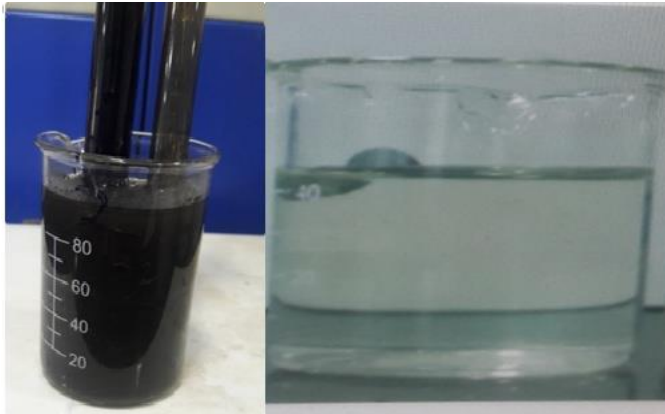


**Chart -2:** TURBIDITY INPUT AND OUTPUT REMOVAL

**3.3 Interpretation of Results**

- We found that there was very good efficient in the removal of TSS and Turbidity.
- The proposed output was achieved to good extent.
- % removal= { ( Input – Output)/ Input } \* 100
- We found TSS removal of 95% -99%.
- We found Turbidity removal of 97% - 99%.
- Other parameters have slight variations when compared to input quality and which are within the limits.
- TDS removal has slight variations.
- All are parameters were within the limits.

- Within short retention time around 8-10minutes the process was completed.
- Micro-sand floc formed is of 1mm in size.
- The sludge is collected in the sludge hopper which is pumped to hydro-cyclone for separation of micro-sand and sludge.
- Hence we can say this process has achieved good efficient in removal of TSS and Turbidity within short span of time.
- The sludge separated was sent to filter press where the water is removed and dewatered sludge is again sent to micro-pellet plant.



**Fig -8: ACTIFLO INPUT AND OUTPUT**

#### 4. CONCLUSION

Actiflo process has found an effective alternative for conventional wastewater treatment. The effectiveness, efficient and consistent treatment of this process along with its small footprint, short retention time, increased rise rates make it a cost effective. The use of micro-sand in this process provides high rate settling with formation of ballasted flocs. It also found its effectiveness in large fluctuations of effluent. This process found very efficient in the removal of TSS and turbidity of 95%-99% and 97%-99%. The sludge produced from this process was dewatered, thickened and reused for micro-pellet plant. Finally, we can conclude that this is one of the new innovative and developing technologies for wastewater treatment. This has found its applications around worldwide and developing too

#### REFERENCES

- [1] Baneerjee K Blumenschein C D – High speed micro-sand settling: an innovative process to control water pollution, May 2001, Tampa.
- [2] Carsten R. Peterson Claus P.Dahl Victoria Plum N.B. Thomsen-The Actiflo Method, (1998) vol 37, No 1, 269-275 wat.sci.tech.
- [3] Delsalle F. Binot P, Guibelin E-The Actiflo process: A highly compact and efficient process to prevent water pollution,(1994) 30, No 1, 87-96.
- [4] Erica Latker and Blumenschein Charles D, Kashi Baneerjee-Sand Ballasted High Rate Clarification Process for Treatment, IWC 06-20.

- [5] Ghilaine Charrade, Cristina Dambrosio- An innovative process for treatment of mining effluent (2014), S3-14.
- [6] Jason Jacobsen, Sun-Nan Hong-Micro-sand Ballasted Flocculation and Clarification for the High Rate Treatment of Storm Waters and Sewer Overflows, water shed 2002.
- [7] J. Sanz, L.Guerrero, J M Ortega-Application of New Solution Actidisc on Secondary Effluent Reclamation in Castellon de la Plana (2006).
- [8] Prof. Dr. Mohammad A.M Al-Tufally, Babylon University- Modeling of Actiflo Water supply Treatment Plant, Iraq-2010.
- [9] Rick Jeschke, David Hansen- Water Quality Data from a Full Scale Micro-sand Ballasted Flocculation and Clarification Plant presented at 1999 AWWA conference Chicago on June 20-23.