Oct. 2021

# Project Completion Report
# IN-SITU NANOBUBBLE TREATMENT OF SEWERAGE TREATMENT PLANT (WSP) AT FAZILKA, PUNJAB

**Assigned and Supported by:**

**PUNJAB POLLUTION CONTROL BOARD**

**VATAVARAN BHAWAN, NABHA ROAD PATIALA, PUNJAB**

**Implemented By:**

**NANOBUBBLES TECH (P) LTD.**

**PLOT NO. 496, INDL. AREA PH – IX, SAS NAGAR (MOHALI) PUNJAB**

11/11/2021

# Contents

## Introduction and Background of the Report

The report compiles the details of the project for practical demonstration of In – Situ Nanobubble generation technology and its benefits for Wastewater treatment. The report also discusses the methodology adopted for implementation of technology and results of the study.

## The technology utilized for the project

The project is based on In – Situ Nanobubble Generation Technology. The technology of Nanobubble generation involves introduction of Nanobubbles which are miniature size gas bubbles in liquids, less than 200 nm in diameter. These bubbles are generated by applying the shear resistance relationship between the interface of the object and the adjacent area. When gas (e.g., oxygen) is split into nano size by the sheer force generated at the interface of the object, dissolved gas is increased. Thus, Nano-sized bubble (gas) exists in water for a long time without degassing, and level of dissolved gas is maintained high for a long time.

Thus, due to the unique characteristics of Nanobubble they offer innumerable advantages:

- Nanobubbles remain stable in water for longer periods because of their negatively charged surface (zeta potential).
- The internal pressure of nanobubbles in liquids is much higher than that of their environment, which helps in very efficient dissolution of the gas into the liquids
- While rising in water, the collapsing nanobubbles generate free radicals that catalyze chemical oxidation reactions.

The remarkable properties of nanobubbles explained above offer multidimensional applications in the innumerable industrial, domestic applications in the fields of science and technology, including Agriculture, Aquaculture, Drinking Water treatment, Wastewater Treatment etc.

The KBK Environ infrastructures Limited and Nanobubbles Tech Private Limited from KBK GROUP have been doing extensive work on application

of oxygenated nano-bubbles for cleaning of water bodies since 2019. Globally, the oxygenated nanobubbles are a proven technology which uses only air as an input. International Research Bodies have already documented that oxygenated nanobubbles are an effective solution for enhanced productivity of Crops, Poultry, Dairy Farming and fisheries in addition to water treatment. However, their application in India is till questioned. Thus, KBK Group Companies took the lead for implementing research projects and testing the technology in Indian scenario.

This report compiles the application of Nanobubble Generation Technology in wastewater treatment sector in Sewerage Treatment Plant (WSP) Fazilka. The project has been implemented with administrative and logistic support of Punjab Pollution Control Board (PPCB) as per mandate of National Green Tribunal (NGT) (Ref. OA No. 593/2017 titled as Vikram Ahuja Vs. State of Punjab & Others). (Annexure 1)

## Methodology of the Project

### Details of the Equipment

The project involved installation of the Nanobubble generating equipment developed by M/s Nanobubbles Tech (P) Limited, for a practical demonstration of In – Situ Nanobubbles Generation Technology in wastewater industry. The two models of Nanobubbles Generator Machines i.e. NBTECH 60 and NBTECH 10 were utilized for the study.

### Performance Validation of the Nanobubbles Generator Machines Manufactured by KBK GROUP by IIT Ropar

Dr Neelkanth Nirmalkar from Department of Chemical Engineering Indian Institute of Technology, Ropar evaluated the quantum and performance of the Nanobubbles and issued a performance report in 2019 on the application and characteristics of nanobubbles generated from the nanobubble generator equipment manufactured by KBK Group. (Annexure )

The experimental results summarised that the Typical bubble number density released from the equipment is found to be 8 1.18 10 × bubbles/mL (100 million bubbles per mL at 4.8 bar saturation pressure) which translates into 14 : 1.18 10 × bubbles/mL per hour for 10 m3 /hr capacity machine. Also, the

mean diameter of the nanobubbles was determined and found to be 100-150 nm which is good for the enhancement of the oxygen in the water bodies. So smaller the size better the dissolved oxygen in the water. The evidence of nanobubbles were examined by freezing and thawing techniques. 96% of nano entities were observed to be gas filled nanobubbles. Recirculation mode enhances the DO level by 6-fold. Increase in the electrical conductivity denotes formation of free ions in the water which is good for killing the harmful microorganism. Nanobubbles were found be stable more than a week.


Fig. 1 The Nanobubble generating equipment (NBTECH 10) developed by M/s Nanobubbles Tech (P) Limited utilized for the study.

The features of NBTECH 10 and NBTECH 60 utilized for the project are given below:

NBTECH 10

- Generates Trillions of Nanobubbles by processing Effluent/Sewage Water @10M^3 per hour. Can treat upto 100 M^3 per hour.
- Oxygen purging@10 LPM
- Power: 5 KW, Calpeda Pumps.
- Can be installed at site in a few days.
- Increases Dissolved Oxygen (DO) levels rapidly
- Removes bad smells
- Decomposes sludge at the bottom of the water body
- Stimulates self-purification to recover clean water environment
- Degradation of organic compounds, reduction of excess nutrients and elimination of floating algae
- Kills anaerobic microbes and promotes aerobic microbes

NBTECH 60

- Generates trillions of Nanobubbles by processing effluent/sewage water @60Mt^3 per hour. Can treat up to 600 M^3 per hour.
- Oxygen/Ozone Purging @100 LPM.
- Power: 8 KW, Pump from Calpeda, Italy
- Can be installed at site in a few days.
- Built in Ozone Generator
- Increases Dissolved Oxygen (DO) levels rapidly
- Removes bad smells
- Decomposes sludge at the bottom of the water body
- Stimulates self-purification to recover clean water environment
- Degradation of organic compounds, reduction of excess nutrients and elimination of floating algae
- Kills anaerobic microbes and promotes aerobic microbes

## Details of the scientific study and stages

The methodology involved introduction of Nanobubble to three maturation ponds of the Sewerage Treatment Plant (WSP). (as given in Fig, 2) Nanobubbles have been introduced in three maturation ponds during July 2021 to August 2021.

The machines (as shown in Fig, 1) have been introduced regularly as per the machine operation summary given during the period of 11$^{th}$ July 2021 to 12$^{th}$

August 2021 varying from minimum 4 hour to 18 hours on each day. The details of the machine operation for each day with details of the operation time are given in Table 1, 2 and 3.

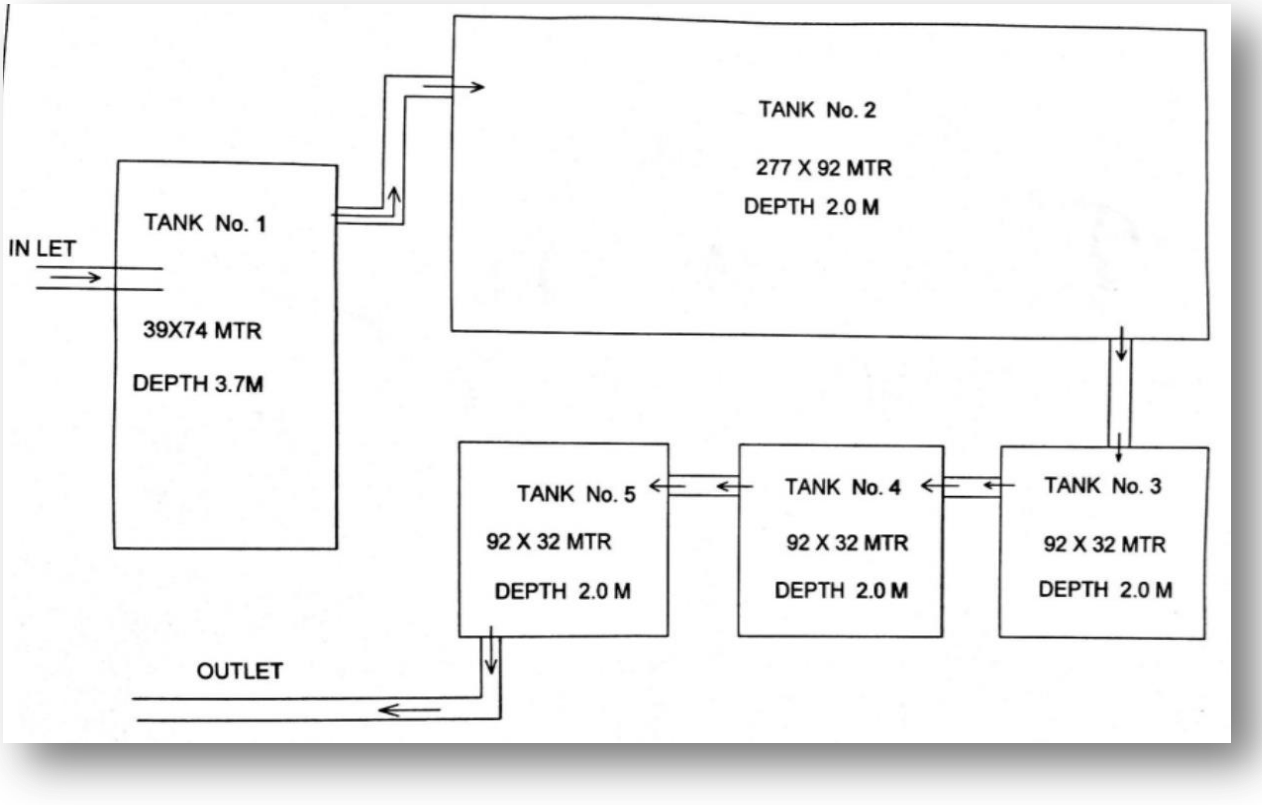



Fig. 2 The Layout Of The Sewerage Treatment Plant (WSP) at Fazilka of 8 MLD Capacity, wherein the Nanobubble treatment has been introduced in tank no. 3 for 6 Days (from 7th August to 12th August) , Tank no. 4 for 14 days (from 24th July to 6th August) and Tank No. 5 for 32 days (from 12th July to 12th August), as per the treatment summary discussed in Table 1, 2 and 3.

Table 1: Machines Operation Summary

| S. No. | Duration of the study | Pond No./ Treatment Provided |
|---|---|---|
| 1. | 12th July 2021 to 23rd July 2021 | Tank no. 5 was given Nanobubble treatment with 2 machines |
| 2. | 24th July 2021 to 12st August 2021 | Tank no. 5 was given Nanobubble treatment with 1 machine. |
| 3. | 24th July 2021 to 6th August 2021 | Tank no. 4 was given Nanobubble treatment with 1 machine. |

Table 2 Operation Chart 1 – NBTECH 60

| NBTECH 60 | | | | | |
|---|---|---|---|---|---|
| S. No. | | Machine Date / Time | | Operation | No. of Hours run |
| | Pond treated | Date | Time of Start | Time of Stop | |
| 1 | 5 | 11 July 2021 | 11.00AM | 6.00PM | 7 |
| 2 | | 12 July 2021 | 1.30PM | 6.00PM | 4½ |
| 3 | | 13 July 2021 | 8.30AM | 6.30PM | 10 |
| 4 | | 14 July 2021 | 8.00AM | 6.30PM | 10½ |
| 5 | | 15 July 2021 | 8.00AM | 6.30PM | 10½ |
| 6 | | 16 July 2021 | 8.00AM | 6.30PM | 10½ |
| 7 | | 17 July 2021 | 8.00AM | 6.30PM | 10½ |
| 8 | | 18 July 2021 | 6.00AM | 2.00PM | 8 |
| 9 | | 19 July 2021 | 8.00AM | 6.30PM | 10½ |
| 10 | | 20 July 2021 | 8.00AM | 6.30PM | 10½ |
| 11 | | 21 July 2021 | 8.00AM | 6.30PM | 10½ |
| 12 | | 22 July 2021 | 8.00AM | 6.30PM | 10½ |
| 13 | | 23 July 2021 | 8.00AM | 6.30PM | 10½ |
| 14 | 4 | 24 July 2021 | 8.00AM | 6.30PM | 10½ |
| 15 | | 25 July 2021 | 6.00AM | 2.30PM | 8½ |
| 16 | | 26 July 2021 | 8.00AM | 7.00PM | 11 |
| 17 | | 27 July 2021 | 8.00AM | 6.00PM | 10 |
| 18 | | 28 July 2021 | 8.00AM | 6.30PM | 10½ |
| 19 | | 29 July 2021 | 8.00AM | 6.30PM | 10½ |
| 20 | | 30 July 2021 | 8.00AM | 6.30PM | 10½ |
| 21 | | 31 July 2021 | 8.00AM | 6.00PM | 10½ |
| 22 | | 01 August 2021 | 6.00AM | 2.30PM | 8½ |
| 23 | | 02 August 2021 | 8.00AM | 6.30PM | 10½ |
| 24 | | 03 August 2021 | 8.00AM | 6.30PM | 10½ |
| 25 | | 04 August 2021 | 8.00AM | 6.30PM | 10½ |
| 26 | | 05 August 2021 | 8.00AM | 6.30PM | 10½ |
| 27 | | 06 August | 8.00AM | 6.30PM | 10½ |

| | | | | | |
|---|---|---|---|---|---|
| | | 2021 | | | |
| 28 | 3 | 07 August 2021 | 5.00AM | 11.00PM | 18 |
| 29 | | 08 August 2021 | 5.00AM | 9.00PM | 16 |
| 30 | | 09 August 2021 | 5.30AM | 11.00PM | 17½ |
| 31 | | 10 August 2021 | 5.00AM | 11.00PM | 18 |
| 32 | | 11 August 2021 | 5.30AM | 11.00PM | 17½ |
| 33 | | 12 August 2021 | 5.00AM | 11.00PM | 18 |

Table 3 Operation Chart 2 – NBTECH 10

| NBTECH 10 | | | | | |
|---|---|---|---|---|---|
| S. No. | | **Machine Operation Date / Time** | | | **No. of Hours** |
| | **Pond treated** | **Date** | **Time of Start** | **Time of Stop** | |
| 1 | 5 | 11 July 2021 | 10.30AM | 6.00PM | 7½ |
| 2 | | 12 July 2021 | 2.00PM | 6.00PM | 5 |
| 3 | | 13 July 2021 | 8.30AM | 6.30PM | 10 |
| 4 | | 14 July 2021 | 8.00AM | 6.30PM | 10½ |
| 5 | | 15 July 2021 | 8.00AM | 6.30PM | 10½ |
| 6 | | 16 July 2021 | 8.00AM | 6.30PM | 10½ |
| 7 | | 17 July 2021 | 8.00AM | 6.30PM | 10½ |
| 8 | | 18 July 2021 | 6.00AM | 2.00PM | 8 |
| 9 | | 19 July 2021 | 11.30AM | 6.30PM | 7 |
| 10 | | 20 July 2021 | 8.00AM | 6.30PM | 10½ |
| 11 | | 21 July 2021 | 8.00AM | 6.30PM | 10½ |
| 12 | | 22 July 2021 | 8.00AM | 6.30PM | 10½ |
| 13 | | 23 July 2021 | 8.00AM | 6.30PM | 10½ |
| 14 | | 24 July 2021 | 8.00AM | 6.30PM | 10½ |
| 15 | | 25 July 2021 | 6.00AM | 2.30PM | 8½ |
| 16 | | 26 July 2021 | 7.30AM | 7.00PM | 11½ |
| 17 | | 27 July 2021 | 8.00AM | 7.00PM | 11 |
| 18 | | 28 July 2021 | 8.00AM | 6.30PM | 10½ |

| | | | | | |
|---|---|---|---|---|---|
| 19 | | 29 July 2021 | 8.00AM | 6.30PM | 10½ |
| 20 | | 30 July 2021 | 8.00AM | 6.30PM | 10½ |
| 21 | | 31 July 2021 | 8.00AM | 6.30PM | 10½ |
| 22 | | 01 August 2021 | 6.00AM | 2.30PM | 8½ |
| 23 | | 02 August 2021 | 8.00AM | 6.30PM | 10½ |
| 24 | | 03 August 2021 | 8.00AM | 6.30PM | 10½ |

Consequently, with respect to the no. hours of operation of the Nanobubble generation equipment at each pond, each pond was exposed to higher levels of oxygen as per the stage wise details given below:

**Stage 1: from 11th July 2021 to 23rd July 2021**

NBTECH 10 and NBTECH 60 were installed for Nanobubble treatment of Pond no. 5 for first 13 days. NBTECH 10 has the capacity to process 10000 ltr / hr and NBTECH 60 can process 60000 ltr / hr.

No. of hours of operation per machine per day – 10 ½ hours (average)
Amount of Oxygen injected as nanobubbles (pond 5) – 400 cubic m of O2

**Stage 2: from 24th July 2021 to 3rd August 2021**

NBTECH 10 treated Pond no. 5 and NBTECH 60 was shifted to treat Pond no. 4

No. of hours of operation per machine per day – 10 ½ hours (average)
Amount of Oxygen injected as nanobubbles (pond 5) – 225 cubic m of O2
Amount of Oxygen injected as nanobubbles (pond 4) – 133 cubic m of O2

**Stage 3: from 4th August 2021 to 12th August 2021**

NBTECH 10 was removed from operation and NBTECH 60 alone was operated to treat Pond no. 4 and Pond no. 3 for last 6 days

No. of hours of operation per day – 18 hours (average)
Amount of Oxygen injected as nanobubles (pond 4) – 72 cubic m of O2

Amount of Oxygen injected as nanobubbles (pond 3)– 210 cubic m of O2

## Monitoring and Sampling during the study

During the project continuous sampling and testing of water samples was conducted by PPCB to scientifically monitor the improvement in the water quality in the inlet and outlet streams of different ponds. The results of the study are discussed in the following sections of the report.

## Results and Discussion of the study

The hourly exposure of Nanobubbles was introduced to the ponds regularly as discussed in the methodology, during the 1month study varying from minimum 4 hours to 18 hours, which cumulatively resulted in increased levels of Dissolved Oxygen (DO) in the treated water. The Level of DO in the treated ponds increased from BDL Pond No. 1 of STP from BDL to 4.8 mg/l in the outlet drain with regular induction of Nanobubbles in the maturation ponds, as per the test results, discussed further in the report. (Copies of the test reports are enclosed as Annexures)

The DO level at the time of start of the treatment in Pond no. 3 was around 0.2 mg/L and it was around 1.8 mg/L after the Nanobubble treatment.

The foul smell from the ponds reduced considerably within 2 weeks of treatment. The quality of water in the ponds also improved in physical appearance as the turbidity levels decreased. The gradual variation in the physical appearance of the pond water quality is evident with Fig.3,4,5 and 6.

Fig. 3 The appearance of the pond before Treatment

Fig.4 The appearance of the pond no. during Treatment

Fig.5 The appearance of the pond after Treatment

Fig. 6 Change in colour and turbidity of water samples during progression of the study

The results of the sampling are given below in Table 4, 5 and 6 while graphical analysis of variation of critical parameters of BOD and COD is depicted in Fig. 7 as given below.

Table 4: Test results of sampling conducted on 16.07.2021

| | **Type of sampling** | | **Grab** | | | |
|---|---|---|---|---|---|---|
| | Date of Sample Collection | | 16.07.2021 | | | |
| | Point of sample collection | pH | BOD | TSS | COD | F. Coli |
| | | | | | | |
| **1** | Pond No. 1 of STP (Inlet ) | 7.8 | 71 | 146 | 234 | 84000 |
| **2** | Pond No. 2 of STP | 7.6 | 62 | 138 | 210 | 70000 |
| **3** | Pond No. 3 of STP | 7.5 | 59 | 134 | 200 | 70000 |
| **4** | Pond No. 4 of STP | 7.5 | 49 | 103 | 168 | 58000 |
| **5** | Pond No. 5 of STP | 7.6 | 38 | 100 | 129 | 21000 |
| **6** | Outlet of STP | 7.4 | 25 | 73 | 98 | 1700 |
| **7** | From U/S of meeting point of sludge carries from Fazilka Drain | 7.5 | 27 | 105 | 108 | 3800 |
| **8** | From D/S of meeting point of sludge carries from Fazilka Drain | 7.6 | 47 | 118 | 158 | 11000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 9 | From Fazilka Drain before meeting with Fazilka Muzzam DCB Drain | 7.6 | 45 | 161 | 141 | 9400 |

Table 5: Test results of sampling conducted on 26.07.2021

| **Type of sampling** | | **Grab** | | | | |
|---|---|---|---|---|---|---|
| **Date of Sample Collection** | | 26.07.2021 | | | | |
| **Point of sample collection** | pH | BOD | TDS | TSS | COD | F. Coli |
| | | | | | | |
| **Pond No. 1 of STP (Inlet )** | 7.9 | 38 | 1085 | 79 | 174 | 32000 |
| **Pond No. 2 of STP** | 8 | 38 | 1049 | 67 | 173 | 31000 |
| **Pond No. 3 of STP** | 7.8 | 39 | 1110 | 65 | 175 | 39000 |
| **Pond No. 4 of STP** | 7.8 | 36 | 1035 | 58 | 169 | 27000 |
| **Pond No. 5 of STP** | 7.8 | 35 | 1039 | 68 | 165 | 26000 |
| **Outlet of STP** | 7.9 | 29 | 978 | 49 | 122 | 17000 |
| **From U/S of meeting point of sludge carries from Fazilka Drain** | 8 | 27 | 1115 | 92 | 134 | 25000 |
| **From D/S of meeting point of sludge carries from Fazilka Drain** | 8.1 | 28 | 1131 | 97 | 141 | 26000 |
| **From Fazilka Drain before meeting with Fazilka Muzzam DCB Drain** | 8 | 19 | 1115 | 87 | 125 | 14000 |

Table 6: Test results of sampling conducted on 13.08.2021

| | **Type of sampling** | | **Grab** | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Date of Sample Collection | | 12.08.2021 | | | | | | |
| | Point of sample collection | pH | BOD | DO | TDS | TSS | COD | F. Coli | Ammo. N |
| | | | | | | | | | |
| **1** | Pond No. 1 of STP (Inlet ) | 7.2 | 43 | BDL | 1362 | 80 | 192 | 46000 | 33.8 |
| **2** | Pond No. 2 of STP | 6.8 | 47 | BDL | 1393 | 84 | 198 | 63000 | 34 |
| **3** | Pond No. 3 of STP | 6.5 | 48 | BDL | 1398 | 81 | 196 | 58000 | 31.9 |
| **4** | Pond No. 4 of STP | 6.3 | 31 | 1.2 | 1297 | 71 | 108 | 11000 | 30.2 |
| **5** | Pond No. 5 of STP | 7.2 | 21 | 1 | 1019 | 69 | 72 | 9200 | 29.4 |
| **6** | Outlet of STP | 7.5 | 20 | 1 | 1012 | 56 | 69 | 9100 | 29 |
| **7** | From U/S of meeting point of sludge carries from Fazilka Drain | 7.6 | 17 | 3.2 | 1060 | 43 | 58 | 7800 | 35.2 |

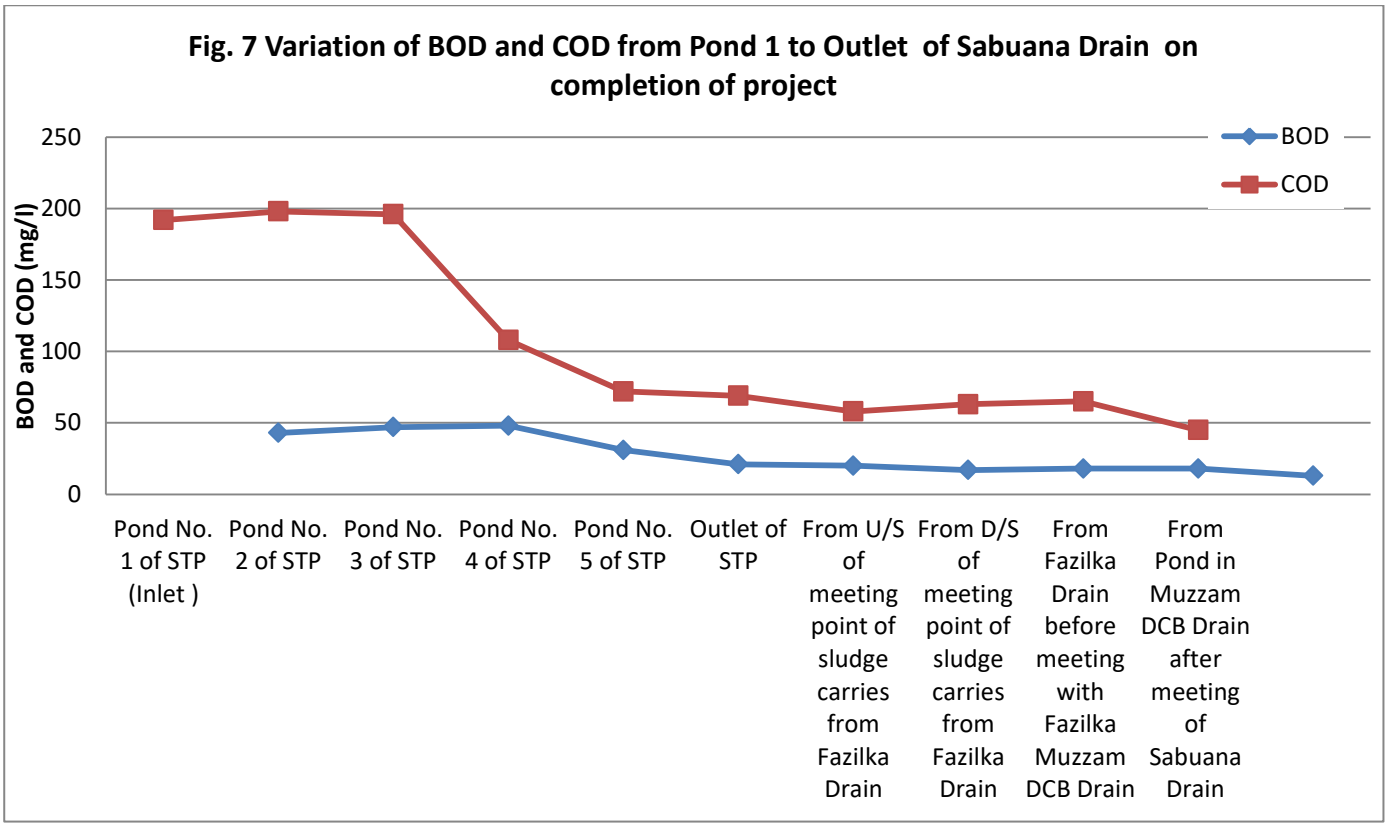
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **8** | From D/S of meeting point of sludge carries from Fazilka Drain | 6.5 | 18 | 3 | 1124 | 54 | 63 | 8100 | 35 |
| **9** | From Fazilka Drain before meeting with Fazilka Muzzam DCB Drain | 6.3 | 18 | 4.1 | 1165 | 58 | 65 | 9100 | 36.1 |
| **10** | From Pond in Muzzam DCB Drain after meeting of Sabuana Drain | 6.8 | 13 | 4.8 | 1002 | 39 | 45 | 1200 | 27.2 |

The COD of a wastewater is the amount of oxygen required to chemically oxidize organic matter in your wastewater into inorganic matter, whereas BOD is the amount of oxygen required to **biologically oxidize** the organics in your sample, usually after 5 days or 21 days of incubation time, depending on the bioassay followed.

The ratio of BOD/COD of a wastewater is a good indication of how much of the total organic load (or oxygen demand) is bioavailable for degradation.

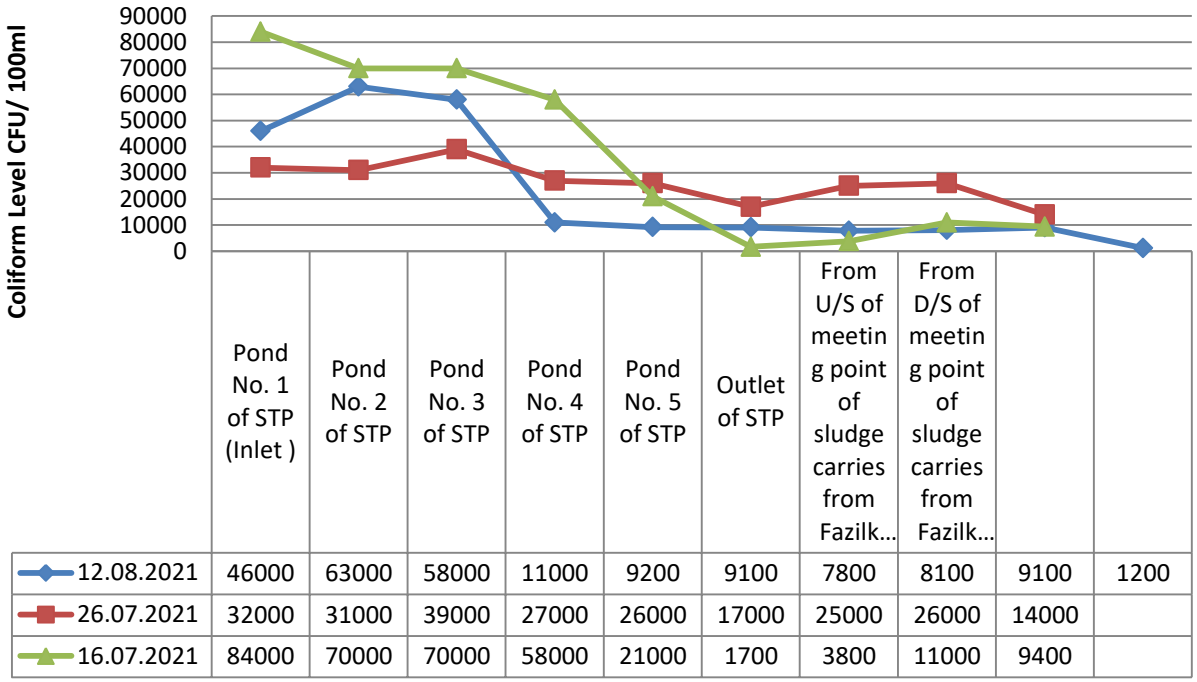
Typical values for the ratio of BOD/COD for untreated municipal wastewater are in the range from **0.3 to 0.8**. If the BOD/COD ratio for untreated wastewater is 0.5 or greater, the waste is considered to be easily treatable by biological means.

Thus, Fig. 7 depicts the decreasing levels of BOD and COD from Pond 1 to Outlet of Sabuana Drain on completion of project, and hence decreased organic load in the outlet water stream. Consequently, it is indicating the increased levels of Dissolved Oxygen as per Test results of sampling conducted on 26.07.2021 (Table 6) and hence improved water quality at the outlet.




Further, a study of variation of Faecal Coli (F. Coli) at all stages of treatment shows a gradual decrease in the count and 1200 on sample collected on 12.08.2021 (Fig. 8) due to effect of Nanobubble treatment and free radical discharge during the process vis-à-vis reduction of BOD reduces the availability of feed for survival and multiplication of F. Coli.

**Fig. 8 Variation of Faecal Coliform count during stages of treatment**




| | Pond No. 1 of STP (Inlet ) | Pond No. 2 of STP | Pond No. 3 of STP | Pond No. 4 of STP | Pond No. 5 of STP | Outlet of STP | From U/S of meeting point of sludge carries from Fazilk... | From D/S of meeting point of sludge carries from Fazilk... | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 12.08.2021 | 46000 | 63000 | 58000 | 11000 | 9200 | 9100 | 7800 | 8100 | 9100 | 1200 |
| 26.07.2021 | 32000 | 31000 | 39000 | 27000 | 26000 | 17000 | 25000 | 26000 | 14000 | |
| 16.07.2021 | 84000 | 70000 | 70000 | 58000 | 21000 | 1700 | 3800 | 11000 | 9400 | |

## Economic viability of the Nanobubble generation technology

As per the conventional technology utilizing the aeration techniques though air blowers and other biological treatment systems, the investment required for 1 MLD plant is 2 crores while for an 8 MLD plant it is 16 crores respectively. Consequently, the operational cost of the conventional systems is 20 to 22 lacs per month. In addition, it takes years to implement a project.

Whereas a wastewater treatment plant of 8 MLD utilizing Nanobubble generation system required CAPEX investment of 2 crores and can be implemented within a few months. The operational cost works out to be Rs. 10,0000 to 15,0000 Per Month. Thus, the comparison of capital and operational costs and time needed to implement the wastewater treatment utilizing conventional vis-à-vis Nanobubble generation technology proves later to be an economical viable and quick fix option for future.

## Brief about Additional Studies already implemented

## The Evaluation of the Nanobubbles Treatment by Water Technology Center (IARI) PUSA DELHI

The Initial Studies conducted by Water Technology Center, IARI Delhi wherein quantity 100000 litres per day of sewage was treated for 10 days. The study (along with other three consequent studies) utilized 10 M^3 per hour capacity machine with 10 LPM oxygen induction. The study was conducted in Nov. 2019, under the guidance of Dr. Ravinder Kaur, Principal Scientist, Water Technology Ceter (WTC) Indian Agricultural Research Institute (IARI), PUSA Campus, New Delhi. The study was conducted for testing and validation of oxygenated Nanobubbles generator machine, for treatment of Sewage water. During the trials regular changes in BOD (5 day) levels of sewage water body were monitored on daily basis while administering Nanobubbles in it for 12 days, and again BOD (5 day) levels were monitored twice at an interval of 15 days after nanobubble generator was removed. The results showed continuous decrease in levels of BOD in water. As the BOD readings continued to decrease even after de-installation of nanobubble generator from the site, thus, it supports the characteristic of nanobubbles to have long residence time in the water varying from days to months. (Annexure )

Table 7: Results of Nano Bubble Treatment at STP, Water Technology Center IARI, PUSA Complex, Delhi

| Date | | BOD (5d) |
|---|---|---|
| 10-12-2019 | R1 | 98 |
| **Bubbler installed in AN** | R2 | 70 |
| | R3 | 58 |
| | Mean | 75.33 |
| | SD | 20.53 |
| 11-12-2019 | R1 | 92 |
| | R2 | 80 |
| | R3 | 94 |
| | Mean | 88.67 |
| | SD | 7.57 |
| 12-12-2019 | R1 | 146 |
| | R2 | 76 |
| | R3 | 78 |

| | | |
|---|---|---|
| | Mean | 100.00 |
| | SD | 39.85 |
| 13-12-2019 | R1 | 60 |
| **Heavy rain until 14 th morning** | R2 | 56 |
| | R3 | 30 |
| | Mean | 48.67 |
| | SD | 16.29 |
| 16-12-2019 | R1 | 56 |
| | R2 | 52 |
| | R3 | 60 |
| | Mean | 56.00 |
| | SD | 4.00 |
| 17-12-2019 | R1 | 104 |
| | R2 | 102 |
| | R3 | 102 |
| | Mean | 102.67 |
| | SD | 1.15 |
| 18-12-2019 | R1 | 110 |
| | R2 | 104 |
| | R3 | 112 |
| | Mean | 108.67 |
| | SD | 4.16 |
| 19-12-2019 | R1 | 100 |
| | R2 | 100 |
| | R3 | 126 |
| | Mean | 108.67 |
| | SD | 15.01 |
| 20-12-2019 | R1 | 18 |
| | R2 | 16 |
| | R3 | 30 |
| | Mean | 21.33 |
| | SD | 7.57 |
| 21-12-2019 | R1 | 36 |
| | R2 | 14 |
| | R3 | 20 |
| | Mean | 23.33 |
| | SD | 11.37 |

| | | | |
|---|---|---|---|
| 23-12-2019 | | R1 | 44 |
| Bubbler removed | | R2 | 56 |
| | | R3 | 46 |
| | | Mean | 48.67 |
| | | SD | 6.43 |
| 02-01-2020 | R1 | | 24.00 |
| | R2 | | 32.00 |
| | R3 | | 27.33 |
| | R4 | | 38.00 |
| | Mean | | 30.33 |
| | SD | | 6.07 |
| 20-01-2020 | R1 | | 26.67 |
| | R2 | | 25.33 |
| | R3 | | 27.33 |
| | R4 | | 32.00 |
| | Mean | | 27.83 |
| | SD | | 2.90 |

Fig.9 & 10 The water status of water quality at Chatamli Water storage tank before Nanobubble treatment. The water is completely filled with algal blooms due to eutrophication and high levels of pollutants.

## Evaluation of the Nanobubbles Treatment by DWSS Punjab:

The nanobubble technology developed by KBK Environ Infrastructures Limited has been also evaluated by Department of Punjab Water Supply and Sanitation for treatment of Sewage water at STP in village Chatamli, Morinda. The wastewater quantity treated was 200000 litres per day. The treatment

continued for 30 Days. (Fig. 9 to 12) The monitoring of samples of STP Chatamli for testing the performance of Nanobubbles Treatment was conducted during the direct treatment with Nanobubble and even after two months of post withdrawal of Machine. Both the monitoring results verified the efficacy and validity of the technology. The samples were tested at PBTI during April – May 2020, and the results (Table 7 & 8) were presented to Niti Aayog and CPCB as well.

**Table 8: Test Results at Village Chatamli, Morinda**

| Sr. No. | Sample Registration No. | Nature of Sample | Customer Code Outlet - Village Chatamli, Morinda, | Result (mg/l) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Parameter | | | |
| | | | | F.Coliform, MPN/100ml | TSS, mg/l | $BOD_3$ at 27°C, mg/l | COD, mg/l |
| | **Treated Effluent (April-May, 2020)** | | | | | | |
| 1 | ENV/040420/000001 | Treated Effluent | dt.04.04.2020 | 79 | 7831 | 311 | **626** |
| 2 | ENV/060420/000003 | Treated Effluent | dt.06.04.2020 | 172 | 495 | 353 | **712** |
| 3 | ENV/070420/000004 | Treated Effluent | dt.07.04.2020 | 348 | 73 | 64 | **280** |
| 4 | ENV/100420/000005 | Treated Effluent | dt.10.04.2020 | 2780 | 118 | 111 | **322** |
| 5 | ENV/130420/000007 | Treated Effluent | dt.13.04.2020 | 1410 | 65 | 95 | **246** |
| 6 | ENV/140420/000008 | Treated Effluentt | dt.14.04.2020 | 7000 | 109 | 44 | **252** |
| 7 | ENV/150420/000024 | Treated Effluent | dt.15.04.2020 | 3480 | 39 | 44 | **196** |
| 8 | ENV/170420/000026 | Treated Effluent | dt.17.04.2020 | 1300 | 65 | 90 | **232** |
| 9 | ENV/220420/000084 | Treated Effluent | dt.22.04.2020 | 2200 | 31 | 50 | **220** |
| 10 | ENV/240420/000091 | Treated Effluent | dt.24.04.2020 | $7X\ 10^3$ | 38 | 29 | **194** |
| 11 | ENV/250420/000108 | Treated Effluent | dt.25.04.2020 | $4.6\ X\ 10^3$ | 51 | 39 | **216** |
| 12 | ENV/250420/000109 | Treated Effluent | dt.25.04.2020 | $2.3X\ 10^3$ | 38 | 31 | **196** |
| 13 | ENV/270420/000110 | Treated Effluent | dt.27.04.2020 | 2210 | 22 | 29 | **152** |
| 14 | ENV/280420/000126 | Treated Effluent | dt.28.04.2020 | 1700 | 42 | 36 | **184** |
| 15 | ENV/290420/000129 | Treated Effluent | dt.29.04.2020 | 2200 | 27 | 29 | **176** |
| 16 | ENV/010520/000134 | Treated Effluent | dt.01.05.2020 | 2210 | 31 | 27 | **180** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **17** | ENV/020520/000145 | Treated Effluent | dt.02.05.2020 | 1700 | 16 | 22 | **176** |
| **18** | ENV/040520/000146 | Treated Effluent | dt..04.05.2020 | 1300 | 15 | 16 | **144** |
| | **Untreated Effluent (April, 2020)** | | | | | | |
| **1** | ENV/040420/000002 | Untreated Effluent | dt.04.04.2020 | $9.4X10^4$ | 320 | 184 | **320** |
| **2** | ENV/130420/000006 | Untreated Effluent | dt.13.04.2020 | $3.45 X 10^5$ | 348 | 157 | **558** |
| | **Treated Effluent (June, 2020)** | | | | | | |
| **1** | ENV/040620/000440 | Treated Effluent | dt.04.06.2020 | < 1 | 135 | 35 | **228** |
| | **Effluent (July, 2020)** | | | | | | |
| **1** | ENV/060720/000924 | nal discharge Outlet of maturation pond | dt.06.07.2020 | 33 | 14.4 | 17 | **200** |
| **2** | **ENV/060720/000925** | **Outlet of anarobic pond receiving raw sewage** | **dt.06.07.2020** | **< 1** | **55.7** | **27** | **296** |

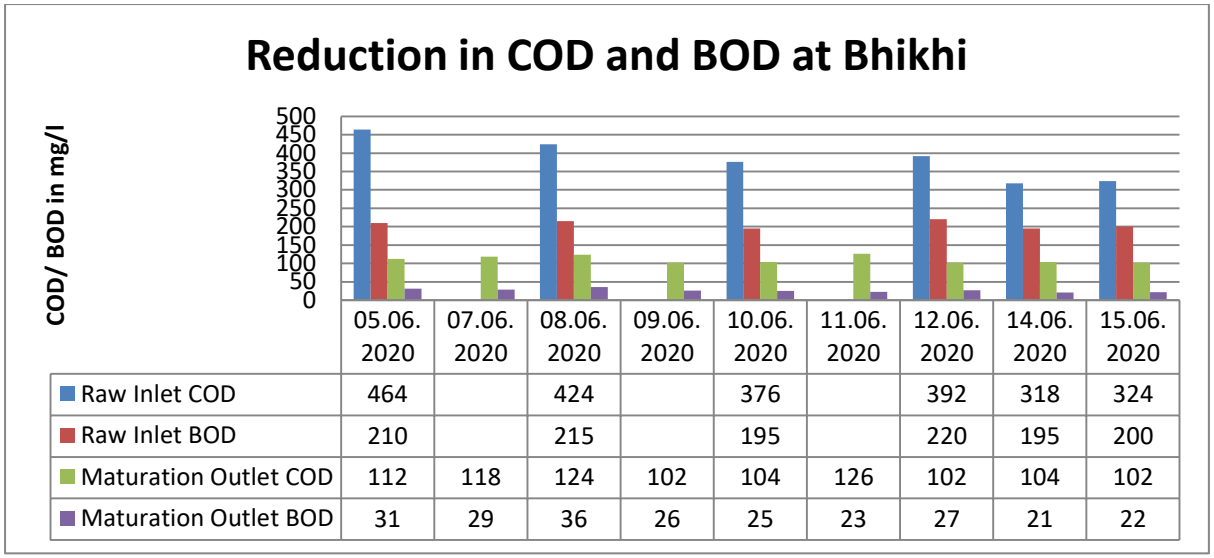
## Evaluation of Nanobubbles Treatment by PWSSB

Additional study has been conducted for testing Nanobubble Technology for treatment of treated water at STP (of 3 MLD Capacity) with Punjab Water Supply and Sewerage Division, Mansa during June 2020 for 30 days, at their Sewage Treatment Plant in Bhikhi (Mansa). (Refer Table 9 and Fig. 13)

Fig.11 & 12 The status of water quality at Chatamli Pond after Nanobubble Treatment. The water is visibly clean and clear with complete removal of algal blooms and any signs of eutrophication.

Table 9: Test Results at Sewage Treatment Plant in Bhikhi (Mansa) after induction of Nanobubble

| | | Raw Inlet | | | | Maturation Outlet | | | | Remarks for Results with treatment |
|---|---|---|---|---|---|---|---|---|---|---|
| **S no** | Date | pH | TSS | COD | BOD | pH | TSS | COD | BOD | |
| **1** | 05.06.2020 | 7 | 294 | 464 | 210 | 7.2 | 34 | 112 | 31 | Normal process in all ponds before installing nanobubble genrator |
| **2** | 07.06.2020 | | | | | 7.6 | 36 | 118 | 29 | |
| **3** | 08.06.2020 | 7.3 | 298 | 424 | 215 | 7.4 | 42 | 124 | 36 | Recharging of Facultative pond after three days |
| **4** | 09.06.2020 | | | | | 7.4 | 28 | 102 | 26 | Recharging of Facultative pond after four days |
| **5** | 10.06.2020 | 7.2 | 278 | 376 | 195 | 7.3 | 32 | 104 | 25 | Recharging of Facultative pond after five days |
| **6** | 11.06.2020 | | | | | 7.4 | 68 | 126 | 23 | Recharging of Facultative pond after six days |
| **7** | 12.06.2020 | 7.5 | 268 | 392 | 220 | 7.6 | 38 | 102 | 27 | Recharging of Facultative pond after seven days |
| **8** | 14.06.2020 | 7.4 | 272 | 318 | 195 | 7.5 | 26 | 104 | 21 | Recharging of Facultative pond and one side scheme is closed for observation |
| **9** | 15.06.2020 | 7.3 | 268 | 324 | 200 | 7.4 | 28 | 102 | 22 | Shifting of machine to anaerobic pond and one side scheme is closed for observation day one |




| | 05.06.2020 | 07.06.2020 | 08.06.2020 | 09.06.2020 | 10.06.2020 | 11.06.2020 | 12.06.2020 | 14.06.2020 | 15.06.2020 |
|---|---|---|---|---|---|---|---|---|---|
| Raw Inlet COD | 464 | | 424 | | 376 | | 392 | 318 | 324 |
| Raw Inlet BOD | 210 | | 215 | | 195 | | 220 | 195 | 200 |
| Maturation Outlet COD | 112 | 118 | 124 | 102 | 104 | 126 | 102 | 104 | 102 |
| Maturation Outlet BOD | 31 | 29 | 36 | 26 | 25 | 23 | 27 | 21 | 22 |

Fig.13: Reduction of COD and BOD in Maturation Outlet vis-à-vis levels of COD and BOD in Raw Water Inlet

Thus, the results at Bhikhi have been very promising, with 70-80 % reduction in COD, and > 80 % reduction in BOD.

## Evaluation of Nanobubbles Treatment By PPCB

During June 2020, Punjab Pollution Control Board (PPCB) was approached with a request for pilot testing of the technology for bio Remediation of Bhullana Drain at District Kapurthala, under the guidance of Chairman, Punjab Pollution Control Board (PPCB), through Zonal Office Jalandhar. (Fig. 14 to 17). The Bhullana Drain continues towards Kapurthala and the quantity of sewage flowing towards it is contributed by 21 villages during its course. The drain was treated for ten days. The performance certificate issued by Punjab Pollution Control Board (PPCB) regarding the results of the studies stated that the technology is most suitable for stationary water bodies in comparison to conventional aeration systems and resulted in decrease in BOD levels up to 65%.

Fig.14 & 15: Inauguration of the Bhullana project in the presence of Chairman Punjab Pollution Control Board (PPCB) and dignitaries from the Govt. of Punjab.

Fig.16 : Project implementing team explaining the technology to Dr. S. S. Marwah, Chairman Punjab Pollution Control Board (PPCB)

Fig. 17 The status of water quality at Bhullana Drain at the start of Nanobubble Treatment.

Thus, conclusively there have been many studies already conducted in various hydrogeological and physiographical settings in Northern India varying from most polluted drains to treated water tanks of STP, to agricultural and fish farms. The technology has so far proven its claimed results at all the project sites. Few of the scientific studies implemented and scientifically recorded have already been discussed above.

Thus, the IIT Ropar certified performance of nanobubbles generator machines developed by KBK Group (Nanobubbles Tech Private Limited and KBK Environ Infrastructures Limited) for application of Nanobubbles technology for cost effective treatment of Sewage stands scientifically validated and proven through various tests conducted by the various government departments as discussed in this report.

Hence, it is humbly requested that KBK GROUP companies (Nanobubbles Tech Private Limited and KBK Environ Infrastructures Limited) be notified as an approved manufacturer and implementor of the NBTECH Nanobubbles Generator Machines for sewage Treatment.

Secondly it is humbly requested that the nanobubbles technology be implemented/integrated by all the Government authorities responsible for sewage treatment at all operational STP projects/ yet to be implemented STP Projects to take advantage of globally established scientific phenomenon of Nanobubbles for improving energy efficiency and performance STP Plants under Govt. sector or under industrial establishments through their CSR funds/ initiatives.