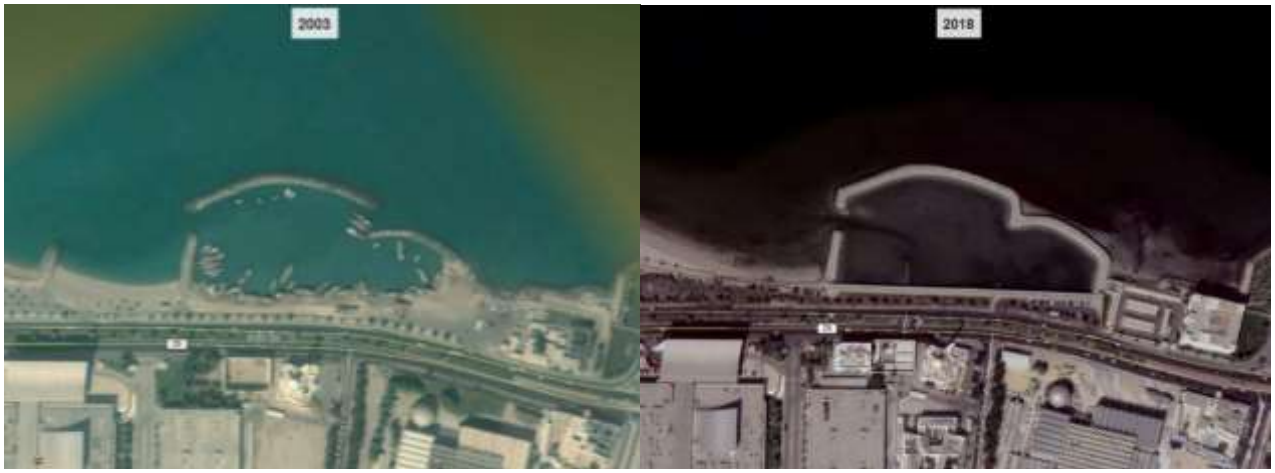
Final Report

A Pilot Project – Enhancing Kuwait Bay Water Quality Using Bio-Products (Ergofito) and Nano-bubbles Generator Technologies to Recover Marine Ecosystem

Author(s)
Mohamed M. Nagib,
Khaleda Makhlouf



Kadhema Scientific Consultancy & Services Co. (KSCS)
State of Kuwait
2018-09-12

Kadhema Scientific Consultancy & Services Co. (KSCS)

Union of Consumer Cooperative Societies Building, 2nd floor, Fourth Ring Road, Hawally

P.O. Box 4492, Safat, 13045, Kuwait

Tel.: +965 22661208 / 22655326 / 22661031

Fax: +965 22661207

Mail: kadehmaenv@kadhema.com

Web: www.kadhema.com

Final Report

A Pilot Project – Enhancing Kuwait Bay Water Quality Using Bio-Products (Ergofito) and Nano-bubbles Generator Technologies to Recover Marine Ecosystem

VERSION
1

DATE
2018-09-16

AUTHOR(S)

Mohamed M. Nagib

Khaleda Makhlouf

CLIENT(S)
Kuwait Environmental Public Authority, (KEPA)

CLIENT'S REF.
Client's reference

PROJECT NO.
KSCS.20.17.024

NUMBER OF PAGES/APPENDICES:
60 + PAGES

ABSTRACT

Kuwait Bay is a semi-enclosed shallow body of water extending approximately 35 km inland. It is an ellipsis-shaped bay at the northwestern edge of Kuwait's territorial waters and covers roughly 750 km². The means the water depth of Kuwait Bay is 5 m, and the maximum depth reaches 20 m at the entrance to the Bay.

During the last few decades, Kuwait's marine environment experienced adverse incidents on a regional and local scale threatening the quality of water and the ecosystem in general. One of that is pollutants which accidentally and frequently happening on the bay which effecting marine ecosystem diversity and production density.

Source of pollutants is; illegal direct sewage discharge through storm water network, power plant discharge, oil spills from port operation or ships activities and dumbed old ships.
The objective of this pilot project is to enhance Kuwait Bay marine ecosystem by using two combined advanced technologies (Nano-bubbles & Bio product) to increase DO concentration to help indigenous microorganisms to treat contamination and enhance seawater quality.

PREPARED BY
Mohamed M. Nagib

SIGNATURE

CHECKED BY
Khaleda A. Makhlouf

SIGNATURE

APPROVED BY
Khaleda A. Makhlouf

SIGNATURE

Document history

VERSION	DATE	VERSION DESCRIPTION
1	2018-09-10	Final report to be submitted to Kuwait Environmental Public Authority (KEPA) for reviewing and prepare comments (if available) or issuing final approval

Contents

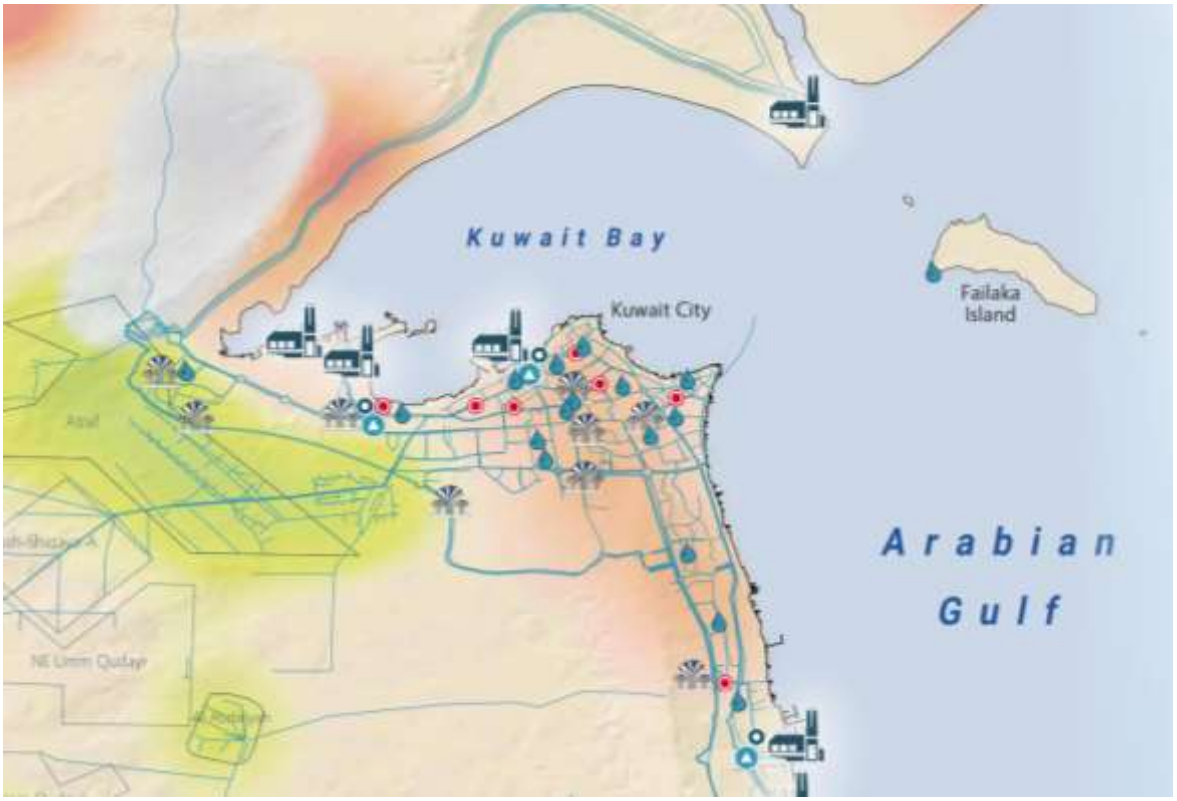
Table of Figures

Introduction

Kuwait's marine environment is a unique ecosystem, characterized by a variety of habitats and wildlife and that clearly manifested in the northern part of Kuwait's waters and Kuwait Bay, the most unique ecosystem in Kuwait's territorial waters. Kuwait Bay is a semi-enclosed shallow body of water extending approximately 35 km inland. It is an ellipsis-shaped bay at the northwestern edge of Kuwait's territorial waters and covers roughly 750 km². The means the water depth of Kuwait Bay is 5 m, and the maximum depth reaches 20 m at the entrance to the Bay. [1]

Kuwait Bay is one of the most prominent features of Kuwait's marine environment. Kuwait Bay, a highly productive ecosystem, provides various services including provisioning, regulatory, supporting and cultural services. Kuwaiti waters particularly the Kuwait Bay are rich in a diversity of species that had supplied about 40% to 50% of the country's food demand. [1]

The maximum current speed was recorded at approximately 1 m/s at the Bay entrance, with the currents slowing towards the western portion of the Bay to < 40 cm/s. [1]



[1] International Journal of Environmental Science and Development, Vol. 5, No. 6, December 2014, N. Al-Mutairi, A. Abahussain, and A. Al-Battay

Figure 1: Graphic map show Kuwait Bay and Water features locations, Beatona[2]

Based on textural characteristics of its sediments, Kuwait Bay is divided into two energy zones. The first is a low-energy zone that includes most of the Bay, with primarily mud sediment. The other zone is a moderate-energy zone restricted to the southern offshore area with primarily sand and sandy deposits. [1]

TABLE II: SUMMARY STATISTICS OF WATER QUALITY IN KUWAIT BAY

	standard	Unit	Mean	Max	Min
DO	4	mg/l	5.8 ± 1.45	9.73	2.1
pH	6.5-8.5	--	8.4 ± 0.03	9.79	7.7
Temp.	-	°C	23.8 ± 0.46	34.8	12
Tur.	-	NTU	15.6 ± 23.7	123	0*
TSS	32.8	mg/l	14.1 ± 4.06	29.1	7.6
NO_3	94.7	µg/l	14.9 ± 28.4	349.31	0*
PO_4	33.7	µg/l	52.8 ± 129.2	1434.3	0*

Temp. = Temperature
Tur. = turbidity
TSS = Total Suspended Solids
*Undetectable limit

Table 1: Showing Summary Statistics of Water Quality in Kuwait Bay, [1]

Due to the extensive aridity of the land and the lack of agricultural resources, most of population has been forced to concentrate in the coastal zone, particularly the southern coast of Kuwait Bay. To meet the population's needs, many governmental and private sector facilities, such as desalination plants, power plants, recreational facilities, hospitals and other urban and industrial facilities, have been constructed along Kuwait Bay's coast. Most of these facilities discharge their effluent directly into the Bay causing severe burdens on Kuwait Bay ecosystem. [1]

On regional scale, the discharges from Shatt Al-Arab also play significant role in variability of water quality of Kuwait marine environment in general and Kuwait Bay in particular. [1]

During the last few decades, Kuwait's marine environment experienced adverse incidents on a regional and local scale threatening the quality of water and the ecosystem in general. One of that is pollutants which accidentally and frequently happening on the bay which effecting marine ecosystem diversity and production density. Source of pollutants is; illegal direct sewage discharge through storm water network, power plant discharge, oil spills from port operation or ships activities and dumbed old ships. [1]

[2] Environmental Monitoring and Information System Kuwait (eMISK), Beatona, KEPA 2016

The objective of this trial pilot study is to enhance Kuwait Bay marine ecosystem by using two combined technologies (Nano-bubbles & ERGOFITO) to treat and enhance seawater quality.

It is evident that if the same pollutants that caused the problem in the first place are still allowed to be discharged at sea, the above-recommended treatment could be futile. It is imperative to stop and treat all discharged pollutants first or in parallel in order to achieve results.

HUMAN

ACTIVITY IS THE MAIN SOURCE OF POLLUTION

INTELLIGENCE IS THE KEY TO REMEDIATION

Preamble:

Pollution in a bay is mostly due to coastal human activities. Sewage, medical waste, municipal waste, ship's waste and many other pollutants find their way in the sea by various means. Rivers, deliberate discharge, wastewater treatment, plants excess capacity etc. is how a bay eventually becomes saturated. Once saturation is achieved, loss of fish, crustaceans, bi-valves and sea plants are the first victims.

Figure 2: Diagram shows main source of Kuwait Bay pollutants.[3]

Humans are the secondary victims as sea pollution leads to an extensive list of health problems as well as possible death due to contact with the polluted water. Eating seafood becomes a hazardous activity.

Under no circumstances, any harsh chemical should be used in polluted sea waters as the secondary problems in a compromised environment will only add to the situation. Nature need nature, hence it requires two natural components working in unison to resolve the sea pollution problem and reactivate the natural balance of the bay. The two natural components are Ergofito natural bacteria and Nano-bubbles to increase the dissolve oxygen level in the bay.

Although the pollution covers a large area it is imperative to treat the bay and oxygenate it in sections as no Nano-bubbles generator large enough does presently exists.

Ergofito will immediately decompose all sewage and make an impossible environment for all pathogens. It will reduce the COD and the TSS by natural decomposition. As we are all aware than when organic decomposition takes place it requires oxygen. Hence the Nano bubble oxygen injection, which will ensure a minimum level of 5 to 6 mg per liter. The by-product will be CO2 and humus (Top soil) which will be beneficial for all life forms. Please refer to Ergofito documentation for technical specifications.

[3] Images Source: Al-Qabas Newspaper- Dated on 10th Jan 2017

Nano-bubbles Technology:

Nano or ultrafine bubbles have a diameter of less than 100 nanometer and unique physical characteristics that differ from other types of bubbles.

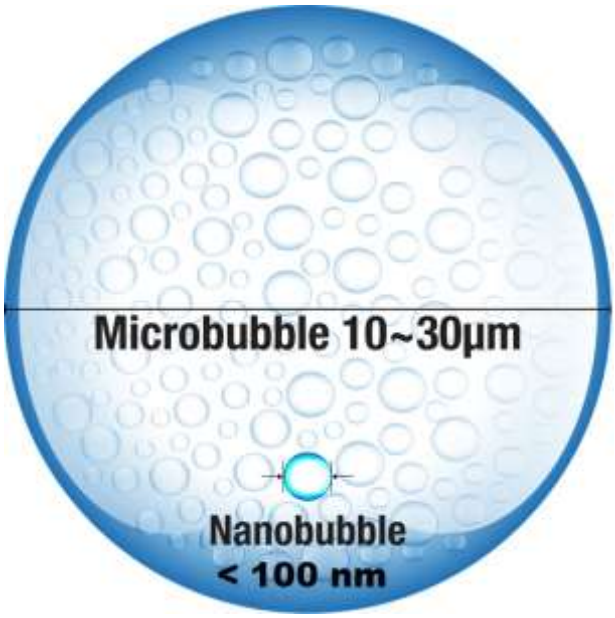
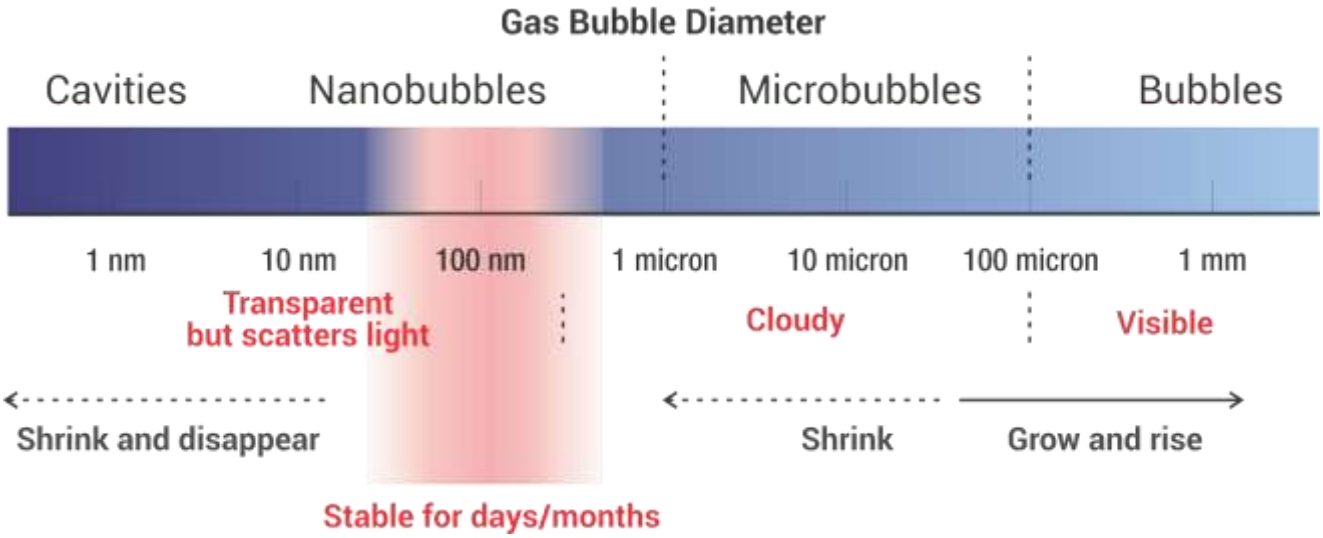


Figure 3: Graphic image shows size difference between Micro & Nano-bubbles.

They are too small to rise up through liquid and get compressed by negative ions at the gas-liquid interface so don't combine to form larger bubbles. This means they remain in liquid for a long time. They then shrink leaving their entire gas load in the liquid.



Nano-bubbles were first discovered in 1894 when the Royal Navy was testing a high-speed torpedo boat. Lord Rayleigh, the legendary classical physicist, investigated further and discovered that micro Nano-

bubbles collapsed and generated high levels of heat and pressure.

Bubble Type	Average Size (mm)	Single Volume (Cubic Microns)	Coarse Bubble Volume Equivalent	Mass Transfer Per Unit
Coarse	6	113,094,000,000.00000	1	1
Fine	1	523,583,333.33000	216	6
Micro	0.001	0.523583	216,000,000,000	6000
Nano	0.000076	0.00023	492,054,235,311,270	78,947.37

Table 2: Comparison table showing the size difference between all types of Bubbles

How it works:

- Nano-bubbles deliver 79,000 times more oxygen mass transfer than standard aeration machines.
- Super oxygenated water creates and sustains rapid aerobic microbial growth.
- Negatively charged bubbles bond to particulates and float them to surface.
- Hydroxyl radicals oxidizes heavy metals.
- Heavier than water, Nano-bubbles fill entire water column and aerates sediment layer.
- Nano-bubbles suspend in water for several months.
- Source of oxygen able to be changed as per application requirements (Ambient air, Ozone and pure oxygen).

Formation of Hydroxyl Radical:

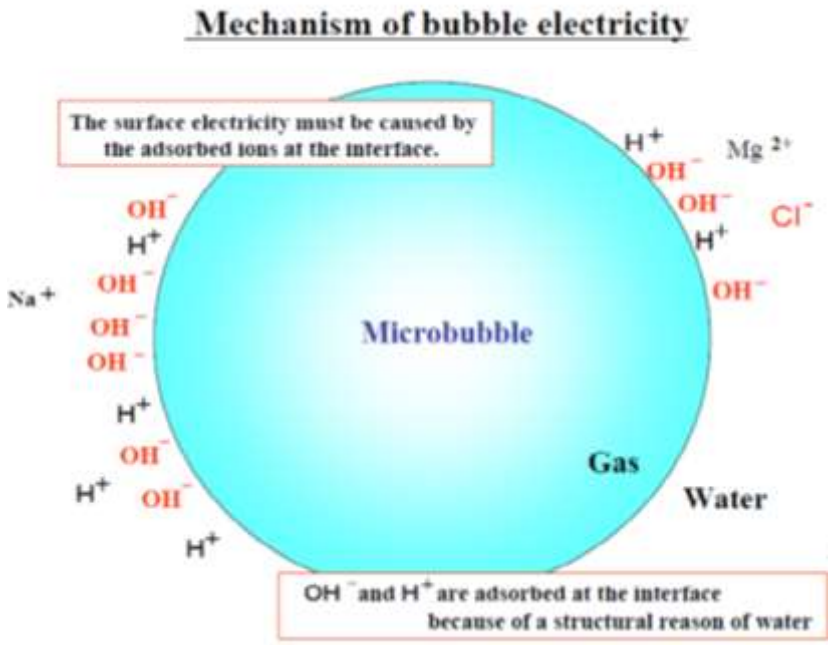
Hydroxyl Radical

Hydroxide is a diatomic anion with chemical formula OH^-. It consists of an oxygen and hydrogen atom held together by a covalent bond, and carries a negative electric charge. It is an important but usually minor constituent of water. It functions as a base, a ligand, a nucleophile and a catalyst.

The corresponding electrically neutral compound -HO is the hydroxyl radical. The corresponding

covalently bound group –OH of atoms is the hydroxyl group.

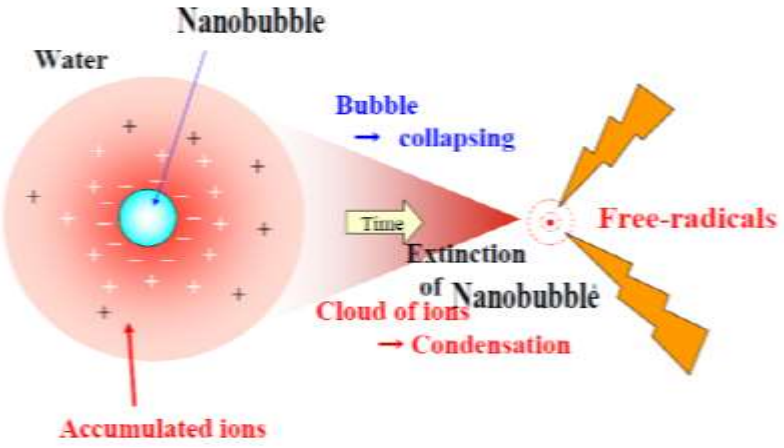
Hydroxide ion and hydroxyl group are nucleophiles and can act as a catalyst in organic chemistry.



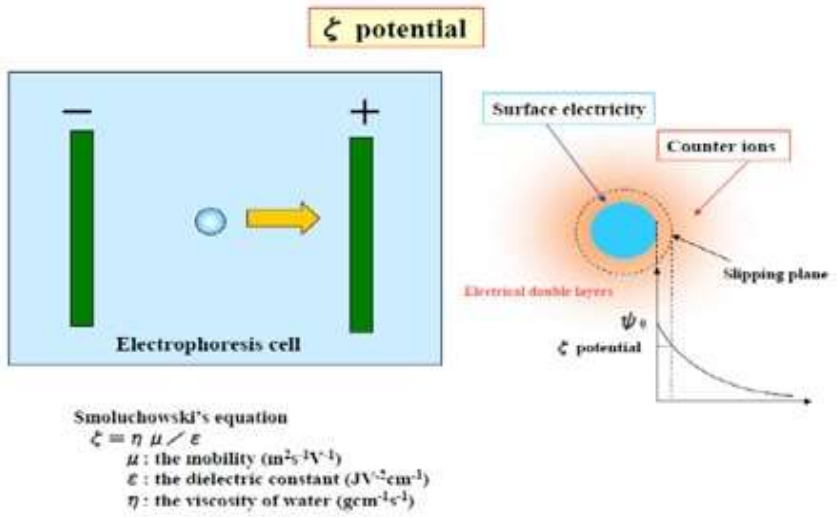
Below 100 nm, our bubbles carry a negative Charge. This is a positive unique feature of Nano-bubbles

Negatively charged bubbles are attracted to positively charged impurities and neutralizes pathogens and anaerobic bacteria naturally without the use of chemicals.

Nano bubble Collapsing Process:



Electrical Charge –Z Potential



Bio-Product Technology (ERGOFITO):

The unique ErgoFito MicroMix formulation was originally developed in Italy, the leading pioneers in bio-enzyme technology. It took 36 years of research and development to perfect the compound they call it now ErgoFito MicroMix. ErgoFito offers products for the Agricultural, Waste Management, Sewage Treatment and Oil Spill remediation markets. ErgoFito's proprietary formulations and exceptional uniformity index, ensures superior quality products with unprecedented and unmatched results. Consequently, the ErgoFito line of products has gained wide support in multiple international markets.

ErgoFito MicroMix product are a powerful tool in environmental remediation and agricultural biotechnology. The core of each product is a unique Bacteria-Enzymatic blend, 100% natural and environmentally friendly, which works synergistically together with other natural agents, to organically decompose & rehabilitate toxic waste elements and convert them into viable nutrients for environment.

ErgoFito BioFlush, is 100% natural and environmentally friendly. With 42 species of bacteria producing many more varieties of enzymes which work synergistically to accelerate bio-degradation naturally.

All organisms remain hydrated throughout the manufacturing and packaging processes, meaning that there are no dormant species, at the time of application. The fact that re-hydration of the bacteria species is not necessary; many stress and efficiency issues prevented. Preserved in their natural polymeric units, their shelf life is 5 years, when stored in ambient, sheltered conditions.

Remediation process description (NANO+ERGOFITO):

- Ergofito is an aerobic microorganism (indigenous Bacteria); it will immediately commence organic decomposition.

- The combination of ErgoFito and sustained oxygen levels will break down all organic pollutants rapidly. It is also will breakdown temperature and pollution stratification, as with Nano-bubbles stratification layers will be impossible to form.
- When Fish, Crustaceans and Bivalvia appear on the shores dead or about to die, this is a big indication of serious situation, which need immediate action.
- Nano-bubbles will aerate the seawater to be between 200,000 and 1,000,000 Nano-bubbles per cubic mm. The air and bacterial application is highly efficient but it will not disturb in any way any ecology that is still present in the body of water.
- Ergofito will break down H_2S, NH_3 in seawater within the first minutes of application. The only by product will be CO_2 and top soil composition. Hydrocarbons will be totally decomposed in the first 30 days.
- Pathogens will be eliminated as the environment necessary for them to survive will by highly compromised by the un-relented bacterial competition delivered by well aerated ErgoFito.
- No chemicals of any sorts are used in this mix, the products are tested/certified by the EPA in the US and many other places in the world, it's safe for all forms of living matter, plants, crustaceans, by-valves, fishes, humans and all that is found in the sea.

Testing Procedure plan:

Testing plan had been defined and agreed between KEPA, Kadhema & EGROFITO Technical teams to be into two deferent stages:

- **First Testing Stage (Kuwait Bay LAB Trial Test).**
- **Second Testing Stage (In-Situ Pilot project).**

First Testing Stage (Kuwait Bay LAB Trial Test):

- Test performed in Kadhema Scientific Consultant HQ based in Hawally, test start date was on Sept. 14, 2017.
- Samples was collected from Shuwaikh Beach area (Next to KPC HQ), samples includes seawater, Sediment and fishes on 14 Sept. 2017 11:00 AM.
- The goal of this study is to evaluate the efficacy and safety of the bio-product "Ergofito MicroMix Aqua & Bioflush" along with Nano-bubbles technologies for enhancement of Kuwait Bay Marine ecosystem.

Figure 4: Image shows different aquarium situation, right tank is (NANO+ERGOFITO) aquarium, left tank is control tank with regular aeriation only (KSCS-Dated 04 April 18).

METHODOLOGY:

Figure 5: Image shows Technical Team during system setup and samples preparation

- Levels and intensity of pollution at sea will vary depending on many natural factors, but it is generally more elevated near the coast, which is the source of the main pollution. Therefore, the application was higher near the shore than further at sea. Al-Shuwaikh Beach is optimal location to collect our testing sample, which was include seawater, sediment and living marine organisms (small fishes- *Liza macrolepis Sp.-Common name MAID*) .

Figure 6: Image shows one of *Liza macrolepis Sp.* (MAID) samples collected from Shuwaikh Beach

- Tanks Volume was 220 Lit/each 25:30 KG Sediment samples installed on each tank, and filled rest of the tank with seawater. Also, *Liza macrolepis Sp.* (MAID) fish was acclimated into the new tanks.
- Over 20 small fish samples was collected from the site with size of 2" length (mature stage). Fishes was really under stress of seawater/weather condition and showing highly death rates once removed from the water.

- The application level for Ergofito MicroMix Aqua & Bioflush for sewage pollution is as follows:

- First application on day 1:

  4 grams of Ergofito MicroMix Aqua

  Nano bubbles applied 24 hours a day on tank aquarium

- Second application on day 2:

  2 grams of Ergofito MicroMix Aqua

  Nano bubbles applied 24 hours a day on tank aquarium

- Third application on day 3:

  2 gram of Ergofito Bioflush

  Nano bubbles applied 24 hours a day on tank aquarium and still working condition in KSCS facility.

- Real-time reading recorded for (DO, TSS, TDS, Ammonia, Sulfide and pH) using calibrated analyzers.
- Periodic water samples was taken for analysis and compared to control water quality report.

LIST OF MATERIAL:

No.	item	QTY.	Image
1	ERGOFITO BIOFLUSH product (1KG) ERGOFITO MICROMIX AQUA product (1KG)	2	

No.	item	QTY.	Image

2	Nano-Bubbles Generator Pilot unit: Dimensions : 100 x 50 x 20 (mm) Distribution Gas Vol. : 60cc/min Water Flow : 5L~20L/min Carbon Ceramic Dim. : ϕ8mm (Pen type) Treating capacity : 200L Material : Transparent PVC Piping outer diameter : ϕ18mm	2	
3	AIR Compressor	1	
4	Water Submersible Pump	2	
5	Air Pressure Mini Regulator	1	
No.	**item**	**QTY.**	**Image**

6	Mini Air Filter	1	
7	200-300 litre fish tank	2	
8	AMMONIA ANALYZER – Ion Selective Probe method	1	
9	Sampling containers for third party testing (Water & Sediment) - if required.	LOT	

No.	item	QTY.	Image

10	DO, COD, pH, TSS, TDS..etc. meter for seawater application	2	
11	Measurement Flasks	LOT	

Test Observations:

1st day observation:

- Sediment Sample: Colour mostly dark black with strong Sulfide smell (rotten egg smell).
- Fish Observation: Week in general and lack of movement noticed.

Figure 7: (Left) image shows seawater color after mixing with sediment, (Right) image shows sediment samples showing contaminated sludge content

2nd day observation:

- Sediment: Grey areas start to be observed and bacterial sludge formation (Activated sludge) start in the fish tank benthic.
- Fish Observation: More Active and Feeding well.
- Sludge formation start to move from the sediment and form in the top layer and aeriated in the

top layer and disappeared, then next batched is formed in sequence the process we called it (Sludge Digestion process).

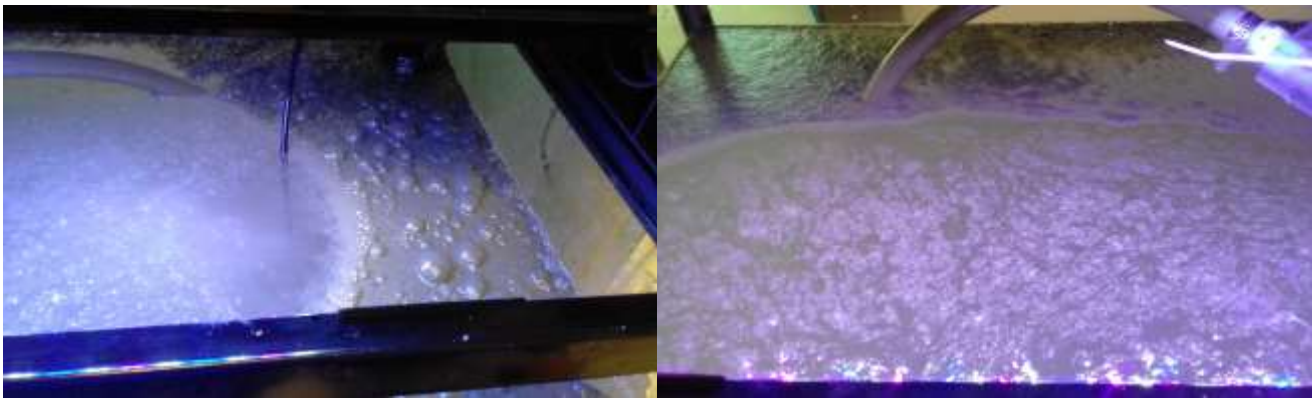


Figure 8: Images shows Sludge digestion process in the (Nano+ERGOFITO) Aquarium

After 5 days observation:

- Sediment: All Sediment top layer turned to Grey sand start formation of Algae activities.
- Fish Observation: More Active and Feeding well.
- All sludge formation on the top layer digested and disappeared.

Figure 9: Images shows testing tank after (5) days of testing and color changing in sediment top layer (Right image)

Testing results:

- Third-party LAB testing results (MEL LAB & AL-CONTROL) for sediment:

Sr.	Parameter/ Item	Unit	Before the treatment (Baseline)	After 60 days of treatment
1	dry weight	wght.-%	<4	<4
METALS				
2	arsenic	mg/kgdm	<4	<4
Sr.	**Parameter/ Item**	**Unit**	**Before the treatment (Baseline)**	**After 60 days of treatment**

3	Cadmium	mg/kgdm	<0.2	<0.2
4	Chromium	mg/kgdm	18	21
5	Copper	mg/kgdm	18	11
6	Mercury	mg/kgdm	0.11	0.19
7	Lead	mg/kgdm	14	<10
8	Nickel	mg/kgdm	16	22
9	Vanadium	mg/kgdm	17	20
10	Iron	mg/kgdm	4800	5500
11	Zinc	mg/kgdm	57	35
INORGANIC COMPOUNDS				
12	Ammonia	mg/kgdm	<26	<26
13	Sulfide (total s)	mg/kgdm	570	16
MINERAL OIL				
14	Fraction C10-C12	mg/kgdm	5	<5
15	Fraction C12-C22	mg/kgdm	50	60
16	Fraction C22-C30	mg/kgdm	120	45
17	Fraction C30-C40	mg/kgdm	100	30
18	Total oil C10-C40	mg/kgdm	280	140
LEACHING				
19	End ph after leaching		8.54	8.57
20	Temperature for PH	°C	18.9	19
21	Conductivity (25°C) after leaching	µS/cm	3050	2520
22	BOD (5 days)	mg/kgdm	93	65
23	COD	mg/kgdm	230	177
Micro-Biology				
24	Heterotrophic plate count	CFU/g moist soil	2.6×10^3	727
25	E.coli MPN method	MPN /100 ml of soil diluted	350	<2

Notice:

✓ Since the trial start till date the seawater never change in the tanks.

- ✓ Fishes shows significant improve of size, health and behaviour.
- ✓ Over a year and still some of *Liza macrolepis Sp.* (MAID) still survived.
- ✓ No special Marine filters used since trial start date.

Figure 10: Image shows the improvement/recovering limits of marine ecosystem after 7 month of testing.

Second Testing Stage (In-Situ Pilot project):

Pilot location:

Among different site locations proposed, KEPA & KSCS finally agreed to choose location next to Al-Seef Palace:

Sr.	Location Name	Total Coverage area	Average water depth/total water mass	Notes
1	Next to Al-Seef Palace	25300 m²	5m/126500 m³	• This location was recommended by KEPA & KSCS • The area is semi closed, enhance the effluent may required less time to be observed comparing with open-sea areas. • Duration: Seawater pollutant level was observed within 1-2 weeks, for sediment it takes around 60:80 days

NOTE: Recommendation for fast and control result area should be almost close and not much human interference that might cause fatal in samples reading.


Proposed Location for Mall
Al-Seef Palace
Kuwait National Museum and Planetarium
National Assembly of Kuwait
Google earth


Measure the distance or area of a geometric shape on the ground
Perimeter:
Area:
Mouse Navigation
Save
Clear

Trial Duration:

For semi closed areas effectiveness was noticed within few days, moreover for odour control material effectiveness was within hours from applying ERGOFITO product. For Meiofauna and plankton tests, the marine ecosystem will need extra time to be recover after reducing pollutants and enhancing seawater quality 2-3 months.

Methodology:

Seawater and sediment samples collected by KEPA & KSCS before the trial to use as a baseline for the trial, moreover every two weeks seawater and sediment samples was collected by KSCS for testing by Third party certified lab, in addition KEPA and KSCS collect another monthly samples including seawater & sediment for chemical and biodiversity tests.

Levels and intensity of pollution at sea are vary depending on many natural factors, but it is generally more elevated near the coast, which is the source of the main pollution. Therefore, the application will be higher near the shore than further at sea. As mentioned above an accurate delivery map will be generated by the prior aerial survey.

The following table describe the ratio of ERGOFITO that was applied to the trial selection area:

Sr.	Date/time	Ratio to be added	Name of product
1	1st Day	2 grams/m³	ERGOFITO MICROMIX AQUA
2	2nd Day	2 grams/m³	ERGOFITO MICROMIX AQUA
3	3rd Day	1 grams/m³	ERGOFITO BIO-FLUSH
4	After 1 month (maintain after heavy sewage discharge)	1 grams/m³	ERGOFITO MICROMIX AQUA
5	After 1 month (maintain after heavy sewage discharge)	1 grams/m³	ERGOFITO BIO-FLUSH
Nano bubbles was fixed to the selected area and applied 24 hours a day.			

- Real-time reading was taking for (DO, TSS, TDS, Ammonia, Sulfide and pH).
- Water samples taken for analysis and compared to control water quality report.

Testing:

The following parameters (for seawater & Sediment), periodically handled by third party laboratory and KEPA LAB before the trial to obtain the study baseline and during & after the trial:

A- <u>Sediment samples:</u>

Pathogens levels (all pathogens) e.g.: E-Coli, Salmonella etc.	Ammonia (Ion Selective method)
Sulfide (Ion Selective method)	Meiofauna species and count as a biological indicator (Sediment sample).
Fat grease and oils	TPH
Heavy metals (to be determined by KEPA)	

B- Seawater samples:

Pathogens levels (all pathogens) e.g.: E-Coli, Salmonella etc.	Ammonia (Probe-Ion Selective method)
Sulfide (Probe-Ion Selective method)	COD
Fat grease and oils	BOD
Heavy metals (to be determined by KEPA)	pH
TDS	TSS
Phytoplankton, Zooplankton & Fish larvae species and count as a biological indicator.	

- Real-time reading should be taking for (DO, TSS, TDS, Ammonia, Sulfide and pH) using probes.

List of Equipment and Material Consumption:

No.	item	Qty	Image
1	ERGOFITO Product (IBCs tanks) – amount of material depends on testing location, pollution concentration and area of testing.	2 IBC	
2	Empty IBC tanks for filling and mixing to dilute the product	2 IBC	
3	ERGOFITO IBC will be fixed with cutter dosing pump, hose & spray nozzle and generator to operate the pump.	set	

No.	item	Qty	Image
4	Nano Bubble generator MK-I: with all electric and piping fittings.	1	
5	Waterproof generator for boat board usage	1	
6	Electric power source, if not available then generator will be needed for Nano bubbles generator operation	1	
7	Underwater camera for seabed observation	1	
8	DO, COD, pH, TSS, TDS, Ammonia..etc. meter for seawater application	sets	
9	Sampling containers for third party testing (Water & Sediment)	**sets**	

No.	item	Qty	Image
10	Boat big enough to carry 1250 kg IBC tank fixed with dosing pump, waterproof generator, hose & spray nozzle and two technician at least.	1	
11	Electric power source (generator)	1	

Trial Duration & work program:

The below schedule is work started once all equipment's/material was delivered to the site:

Sr.	Job Description	Dec 2017	Jan 2018	Feb 2018	Mar 2018	April 2018	May 2018	June 2018	July 2018	Aug 2018
1	**Delivery material to Site**									
2	**Site preparation**									
3	**Start-up & applying the treatment Process**									
4	**Sampling schedule**									

Collecting baseline samples by KEPA & KSCS (28 Dec 2017 & 31 Jan 2018).

Periodic samples every two week by KSCS to third party certified LAB.

Periodic samples monthly by KEPA & KSCS.

- Official start date (13 March 2018).
- Start-up delay was result of MEW delay response for electric power source, finally KSCS used generator for power source.
- Above schedule starts with the official confirmation from KEPA to proceed the trial by collecting all samples to obtain the baseline for the study test.
- National & religious holidays and any other off days shall be added to above schedule.

Baseline testing procedure plan:

Baseline testing procedure plan for KEPA trial project of using advanced technologies (Nano-Bubbles + Ergofito) for Kuwait Bay marine ecosystem enhancement:

6.1.1.1 Sampling locations:

KEPA and KSCS team in parallel will collect seawater and sediment samples from three Stations

Figure 11: Satellite images shows site location and three monitoring stations

Sr.	Station name	Station Coordinates	
1	ST1	29°22'25.60"N	47°57'51.81"E
2	ST2	29°22'25.35"N	47°57'49.28"E
3	ST3	29°22'21.36"N	47°57'48.79"E

A- Seawater Analysis:

KEPA and KSCS team in parallel collected seawater samples from three Stations mentioned above to test by sending it to KEPA & 3rd party LABs to test below parameters:

Sr.	Test Method	Method Descriptions / Reference	Limit of Reporting (mg/L)
1	Temperature	APHA-2130 B	2 mg/L
2	pH	APHA 4500 H+-B	0.01 pH unit
3	Biochemical Oxygen Demand (BOD)	APHA 5210 D	2 mg/L
4	Chemical Oxygen Demand (COD)	APHA 5220 D	15 mg/L
5	Oil & Grease	ASTM D7678-11	0.75 mg/L
6	Total Suspended Solids (TSS)	APHA 2540 D	2 mg/L
7	Total Dissolved Solids (TDS)	APHA 2540 C	10 mg/L
8	Ammonia as NH3-N	HACH 8038	0.02 mg/L
9	Sulphide	According to NEN 6608	0.1 mg/L
10	Copper	Digestion in accordance with NEN-EN-ISO 15587- 1, measurement in accordance with NEN 6966 and NEN-EN-ISO 11885	0.5 -20 µg/L
11	Lead		0.5 -20 µg/L
12	Zinc		0.5 -20 µg/L
13	Heterotrophic Plate Count	APHA 9215 B	<1 CFU/ml
14	Total coliform by Membrane Filtration	APHA 922 B	
15	Fecal coliform by Membrane Filtration	APHA 9222D	
16	E-Coli by Membrane Filtration	APHA 9222 G	<1 CFU/100 ml

B- Sediment Analysis:

KEPA and KSCS team in parallel will collect sediment samples from three Stations mentioned above to be sent to KEPA & 3rd party lab to test below parameters:

Sr.	Test Method	Method Descriptions / Reference	Limit of Reporting (mg/L)
1	Biochemical Oxygen Demand (BOD)	APHA 5210 D	2 mg/L
2	Chemical Oxygen Demand (COD)	APHA 5220 D	15 mg/L
3	Ammonia as NH3-N	HACH 8038	0.02 mg/L
4	Sulphide	According to NEN 6608	0.1 mg/L
5	Metals by ICP (Cu, Zn, Pb,)	Digestion in accordance with NEN-EN-ISO 15587-1, measurement in accordance with NEN 6966 and NEN-EN-ISO 11885	0.5 -20 µg/L
6	Oil & Grease	ASTM D7678-11	0.75 mg/L
7	Total Petroleum Hydrocarbons (TPH)	GC-FID (DIN-EN-ISO 9377-2, ISO/TR 11064)	50 µg/L

Sr.	Test Method	Method Descriptions / Reference	Limit of Reporting (mg/L)
8	Faecal Streptococci by Membrane filtration	APHA 9230 C	< 1 CFU/ 100mL
9	Faecal Coliform by Membrane Filtration	APHA 9222 D	< 1 CFU/ 100mL
10	E-Coli by Membrane Filtration	APHA 9222 G	<1 CFU/100 ml
11	Heterotrophic plate count	APHA 9215 B	CFU/g

- Sediment samples will be collect by Van Veen Grab & Core sampler devices (below image):

C- Mieofauna & plankton test:

Samples for plankton was collected by special plankton nets with mesh net diameters depending on type of plankton, the sampling method described is designed to generate data sufficient to study phytoplankton, zooplankton & fish larvae composition, diversity, abundance and biomass for assessment of ecological seawater quality, the trophic status of Kuwait Bay and setting targets for ecological restoration.

➢ Collect a plankton net sample procedure:

a. Rinse the plankton net and the Cod-end with seawater.
b. Set the tap of the Cod-end to the “close” position and screw the Cod end to the net.
c. Tow the plankton net from MSD to the surface vertically.

d. Set the Cod-end tap to "open" position to empty the Cod-end in a sample bottle and rinse the Cod-end to collect all leftovers.
e. Pull the anchor up and start the boat engine to its minimum speed (very slow)

f. Collect surface samples with plankton net by performing a horizontal towing of the plankton net. To do this hold the net by the side of the boat (while the boat is moving slowly) for approximately 3:5 minutes.
g. Set the Cod-end tap to "open" position to collect the water in to the sampling bottle.
h. Label the sample bottles with the station code and sampling point number, Date and Time of collection.
i. Place the sample bottles in the cooler or wrap them with aluminum foil to protect them from light and place them in as cool as possible place. Might need to add Formaldehyde 5% to fixed the samples.

✓ **Net specifications as per below:**

1- Phytoplankton: by using phytoplankton net with mesh size of 35µm.
2- Zooplankton: by using zooplankton net with mesh size of 150 µm.
3- Fish larvae: by using zooplankton net with mesh size of 325 µm.

D- Onsite readings:

Using testing analyzers to determine online readings (etc. YSI ProDSS & WTW) parameters: Temp, DO, pH, TDS, TSS & EC

Testing results:

6.2.8.1 Baseline testing results:

A. Seawater Sample (28 Dec., 2017):

MEL Labs					KEPA Labs			
Analysis		Stations			Analysis	Stations		
		ST1	ST2	ST3		ST1	ST2	ST3
Metals								
Copper	µg/l	<6	<6	8.8				
Lead	µg/l	15	17	17				
Zinc	µg/l	<20	<20	32				
In-organic compounds								
Sulphide (free) (S2-)	mg/kgdm	<0.1	<0.1	<0.1				
Ammonia-free	mgN/kgdm	0.5	0.4	0.3				
Chemical Analysis								
Temp.	˚c	19	19	19				
pH		8	8	8				
BOD	mg/l	5	6	1				
COD	mg/l	144	140	142				
Oil & Grease	mg/l	<0.75	<0.75	3.1				
TSS	mg/l	129	109	118				
TDS	mg/l	44200	44700	44800				

MEL Labs					KEPA Labs			
Analysis		Stations			Analysis	Stations		
		ST1	ST2	ST3		ST1	ST2	ST3
Ammonia as NH3-N	mg/l	0.5	0.4	0.3				
Microbiology Analysis								
E-Coli	CFU/100ml	279	150	90				
Fecal streptococci	CFU/100ml	<1	<1	<1				
Yeast & Mold	CFU/ml	40	20	<1				
Salmonella		Absence	Absence	Absence				
Staphylococcus aureus	CFU/ml	<1	<1	<1				
Phytoplankton Analysis					**Phytoplankton Analysis**	**Total**	**Mean**	**Cell/l**
					Chaetoceros brevis	76	25	25000
					Chaetoceros laciniosus	10	3	3000
					Chaetoceros pseudocurvisetum	19	6	6000
					Coscinodiscus sp.	7	2	2000
					Fragillaria pacifica	1	1	1000
					Hemiaulus indicus	22	7	7000
					Leptocylindrus danicus	2	1	1000
					Leptocylindrus minimus	2	1	1000
					Melosira Nummuloides	3	1	1000
					Navicula spp.	2	1	1000

MEL Labs					KEPA Labs			
Analysis		Stations			Analysis	Stations		
		ST1	ST2	ST3		ST1	ST2	ST3
					Rhizosolenia stigera	1	1	1000
					Rhizosolenia Stolterfothii	18	6	6000
					Myrionekta rubra	1	1	1000
Zooplankton Analysis					**Zooplankton Analysis**	**Taxa**	**Total**	**Mean**
					Copepod adult	26	3514.211	3514.211
					Copepodite	4	11948.32	11948.32
					Nauplii	1	32732.36	32732.36
					Other Crustacean	9	5622.737	5622.737
					Non Crustacean	13	1004.06	1004.06
					Larvaes	20	5120.707	5120.707

B. Sediment Sample (28 Dec., 2017):

MEL Labs					KEPA Labs			
Analysis		Stations			Analysis	Stations		
		ST1	ST2	ST3		ST1	ST2	ST3
Metals								
Copper	µg/l	330	240	120				
Lead	µg/l	26	24	35				
Zinc	µg/l	200	170	110				

MEL Labs					KEPA Labs			
Analysis		Stations			Analysis	Stations		
		ST1	ST2	ST3		ST1	ST2	ST3
In-organic compounds								
Sulfide(free)(S2-)	mg/l	<1.3	<1.0	<0.7				
Ammonia-free	mgN/kgdm	<12	<12	<12				
Chemical Analysis								
Temp. for pH	°c	20.3	20.4	20.6				
Dry Weight	wght.-%	30.5	40	52				
pH		8.5	8.6	8.7				
Mineral Oil								
fraction C10-C12	mg/kgdm	5	<5	<5				
fraction C12-C22	mg/kgdm	220	50	110				
fraction C22-C30	mg/kgdm	350	230	160				
fraction C30-C40	mg/kgdm	240	170	120				
total oil C10-C40	mg/kgdm	810	450	400				
fat (petroleum ether extraction)		<200	<200	<200				
Meiofauna Analysis					**Meiofauna Analysis**	**Taxa**	**Total**	**Mean**
					Bivalvia	0	20	0
					Ciliata	620	0	30
					Copepoda	10	30	10
					Foraminifera	80	260	430

MEL Labs				KEPA Labs			
Analysis	Stations			Analysis	Stations		
	ST1	ST2	ST3		ST1	ST2	ST3
Meiofauna Analysis				**Meiofauna Analysis**			
				Nematoda	420	11780	4870
				Ostracoda	0	30	0
				Polychaeta	0	0	10
				Tardigrada	0	10	0
				Total	1130	12130	5350

C. Seawater Sample (31 Jan. 2018):

MEL Labs				KEPA Labs				
Analysis	Stations			Analysis		Stations		
	ST1	ST2	ST3			ST1	ST2	ST3
Metals				**Metals**				
Copper µg/l				Copper	µg/l	0.3133	0.311	0.1338
Lead µg/l				Lead	µg/l	0.0243	0.061	0.0521
Zinc µg/l				Zinc	µg/l			
				Iron	µg/l	1.123	1.106	0.602
				Nickel	µg/l	2.262	0.935	0.0788
				Cadmium	µg/l	0.0039	0.015	0.0018
				Vanadium	µg/l	0.0963	0.038	0.0378

MEL Labs					KEPA Labs				
Analysis		Stations			Analysis		Stations		
		ST1	ST2	ST3			ST1	ST2	ST3
In-organic compounds					**In-organic compounds**				
Sulphide(free)(S2-)	mg/l				Sulphide(free)(S2-)	mg/l			
Chemical Analysis					**Chemical Analysis**				
Temp.	°C	20	20	20	Temp.				
pH					pH		8.3	8.43	8.3
BOD	mg/l				BOD	mg/l	2	1	2
COD	mg/l				COD				
Oil & Grease	mg/l				TOC	mg/l	2.450	3.765	2.633
TSS	mg/l				TSS	mg/l	20.8	39.6	57.6
TDS	mg/l				Salinity	ppt.	38.04	38.02	37.8
Ammonia as NH3-N	mg/l				Ammonia as NH3-N	µg/l	27.515	22.615	22.416
					Chlorophyll	mg/m^3	1.95	3.55	1.166
					Phosphate (PO_4-P)	µg/l	70.39	47.32	37.79
					Nitrate (NO_3-N)	µg/l	24.429	23.224	22.1
					Nitrite (NO_2-N)	µg/l	2.64	3.96	3.43
					Silicate (SiO_3-Si)	µg/l	742.68	974.4	826.52
Microbiology Analysis					**Microbiology Analysis**				
E-Coli	CFU/100ml	150	309	142	E-Coli	CFU/100ml	1560	1470	1640
Fecal coliforms	CFU/100ml	210	TNTC	245	Fecal coliforms	CFU/100ml	1560	1470	1780
Heterotrafic plates	CFU/ml	3.2×10^5	306×10^5	3×105^5	Fecal streptococci	CFU/100ml	40	210	80
Salmonella					Salmonella				

MEL Labs				KEPA Labs			
Analysis	Stations			Analysis	Stations		
	ST1	ST2	ST3		ST1	ST2	ST3
Phytoplankton Analysis				**Phytoplankton Analysis(PN)**	**Total**	**Mean**	**Cell/L**
				Bellerochea horologica			
				Chaetoceros curviesetus			
				Chaetoceros chilensis			
				Chaetoceros lorenzianum			
				Coscinodiscus centralis			
				Guinardia flaccida			
				Gyrosigma spp.			
				Hemiaulus indicus			
				Leptocylindrus danicus			
				Navicula spp			
				Nitzschia closterium			
				Nitzschia longissima			
				Odontella mobiliensis			
				Paralia sulcata			
				Pleurosigma elongatum			
				Pleurosigma normanii			
				Rhizosolenia bergonii			
				Rhizosolenia hebetata			
				Rhizosolenia setigera			
				Rhizosolenia stolterfothii			

MEL Labs				KEPA Labs			
Analysis	Stations			Analysis	Stations		
	ST1	ST2	ST3		ST1	ST2	ST3
				Suirella ovalie			
				Thalassionema fraunfeldii			
				Thalassionema nitzchiodes			
				Thalassionema costatum			
				Ceratium furca			
				Ceratium fusus			
				Dinophysis caudata			
				Dinophysis rotundata			
				Gonyaulax digitalis			
				Karenia brevis			
				Scripssiella trochoidea			
				Scripssiella spinifera			
				Noctiluca scintillans			
				Prorocentrum micans			
				Prorocentrum sigmoides			
				Protoperidinium claudicans			
				Protoperidinium depressum			
				Protoperidinium leonis			
				Oscillatoria thiebauti			
Zooplankton Analysis				**Zooplankton Analysis**	**Total**	**Taxa**	**Mean**
				Copepod adult	1178.097	26	1178.10

MEL Labs				KEPA Labs			
Analysis	Stations			Analysis	Stations		
	ST1	ST2	ST3		ST1	ST2	ST3
				Copepodite	1619.884	4	1619.88
				Nauplii	3436.117	1	3436.12
				Other Crustacean	6234.098	31	6234.10
				Non Crustacean	49.08739	9	49.09
				Larvaes	1423.534	13	1423.53
				Copepod adult	25574.53	20	25574.53
				Copepodite	1619.884	26	5546.87
				Total	33281.25	-	1178.10

D. Sediment Sample (31 Jan. 2018):

MEL Labs					KEPA Labs			
Analysis		Stations			Analysis	Stations		
		ST1	ST2	ST3		ST1	ST2	ST3
Chemical Analysis					**Chemical Analysis**			
Temp.	°C	20	20	20				
Microbiology Analysis					**Microbiology Analysis**			
E-Coli	MPN/g	350	500	50				
Fecal coliforms	MPN/g	1100	9000	260				
Heterotrafic plates	CFU/g	TNTC	4.5×10^{5}	2×105^{5}				

MEL Labs				KEPA Labs			
Analysis	Stations			Analysis	Stations		
	ST1	ST2	ST3		ST1	ST2	ST3
Meiofauna Analysis				**Meiofauna Analysis**			
				Acari	0	0	0
				Amphipoda	0	0	0
				Bivalvia	0	33	0
				Bryozoa (Ectoprocta)	0	0	0
				Ciliata	1011	0	49
				Cladocera	0	0	0
				Copepoda	16	49	16
				Cumacea	0	0	0
				Foraminifera	130	424	701
				Gastropoda	0	0	0
				Gastrotricha	0	0	0
				Hydrozoa	0	0	0
				Insecta	0	0	0
				Isopoda	0	0	0
				Kinorhyncha	0	0	0
				Nauplii	0	0	0
				Nematoda	685	19201	7938
				Nematomorpha	0	0	0
				Nemertina	0	0	0
				Oligochaeta	0	0	0

MEL Labs				KEPA Labs			
Analysis	Stations			Analysis	Stations		
	ST1	ST2	ST3		ST1	ST2	ST3
				Ostracoda	0	49	0
				Polychaeta	0	0	16
				Rotifera	0	0	0
				Tardigrada	0	16	0
				Turebllaria	0	0	0
				Unknown	0	0	0
				Total	1842	19723	8720

Scientific Meiofauna test results summary (by KEPA):

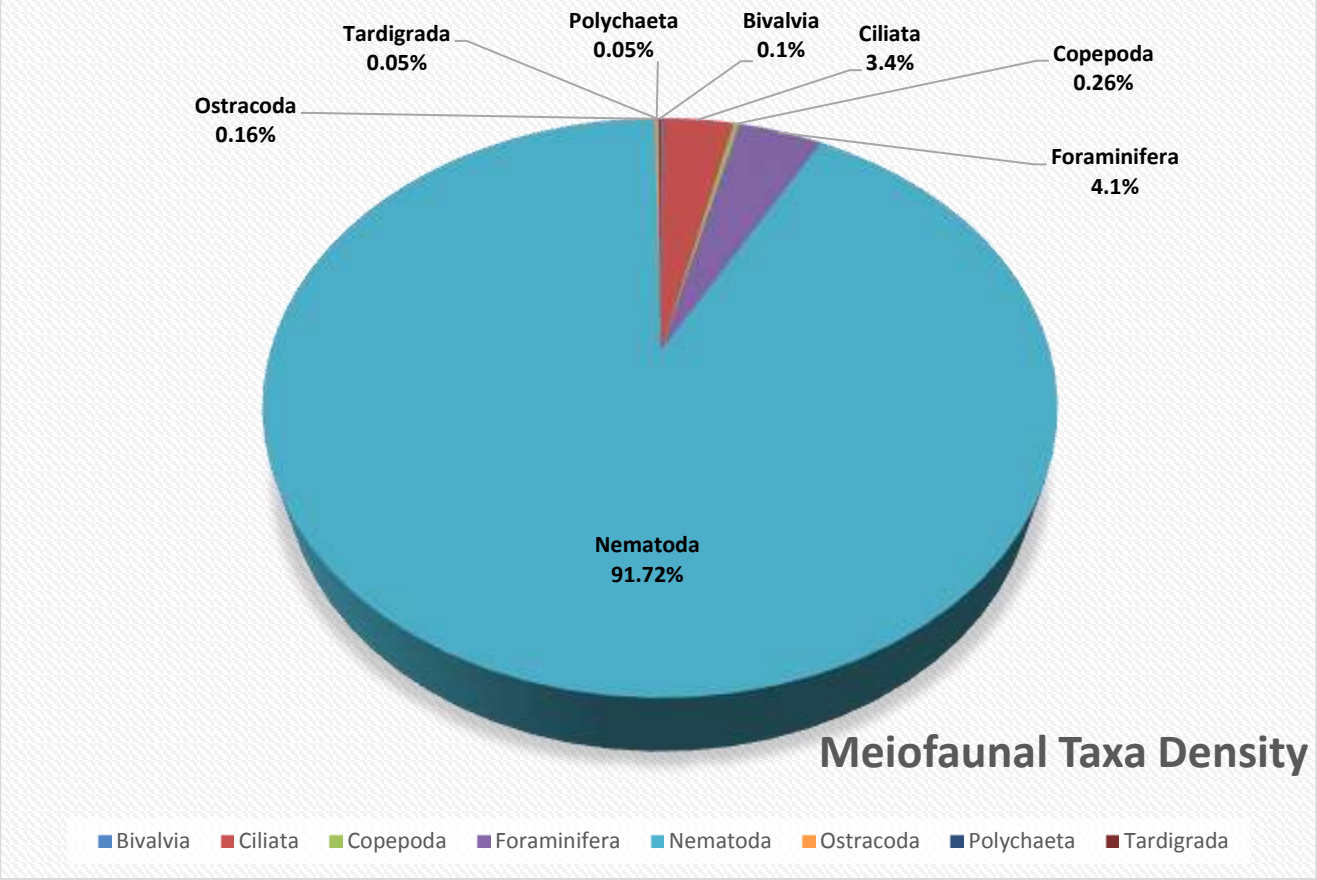
The samples were collected from three stations on two different days 28 Dec 2018 & 31 Jan 2018 from the marina port site (Niqqa). In general, there was a difference in the number of Meiofauna when comparing between the three stations. A difference was found in the types and distribution of the Meiofauna (check summary table below).

The number of Meiofauna ranged from 2972 objects in the first station and the second station was 31902 objects while in the third station was 14070 objects with a total of 48944 and these numbers are relatively regular compared to other sites in Kuwait Bay. Also, results shows that the biological diversity was low, was monitored only 8 varieties of Meiofauna with an average of 5 items per station.

In general (Nematodes) was the largest proportion of animals and was predominant at 91.7% followed by Foraminifera by 7.5% and Ciliata by 3.5%, while the rest of the species are almost negligible. The presence of nematodes is normal, but its presence and the lack of associated species indicate that there is a defect in the environment, which may result from environmental pressures, whether due to natural or abnormal conditions such as contaminants and others, and is likely to result from contamination of the area and the presence of organic matter.

Meiofauna analysis	ST1		Total Per Station	ST2		Total Per Station	ST3		Total Per Station	Total	%
	28-Dec-18	31-Jan-18		28-Dec-18	31-Jan-18		28-Dec-18	31-Jan-18			
Acari	0	0	0	0	0	0	0	0	0	0	0.000%
Amphipoda	0	0	0	0	0	0	0	0	0	0	0.000%
Bivalvia	0	0	0	20	33	53	0	0	0	53	0.108%
Bryozoa (Ectoprocta)	0	0	0	0	0	0	0	0	0	0	0.000%
Ciliata	620	1011	1631	0	0	0	30	49	79	1710	3.494%
Cladocera	0	0	0	0	0	0	0	0	0	0	0.000%
Copepoda	10	16	26	30	49	79	10	16	26	131	0.268%
Cumacea	0	0	0	0	0	0	0	0	0	0	0.000%
Foraminifera	80	130	210	260	424	684	430	701	1131	2025	4.137%
Gastropoda	0	0	0	0	0	0	0	0	0	0	0.000%
Gastrotricha	0	0	0	0	0	0	0	0	0	0	0.000%
Hydrozoa	0	0	0	0	0	0	0	0	0	0	0.000%
Insecta	0	0	0	0	0	0	0	0	0	0	0.000%
Isopoda	0	0	0	0	0	0	0	0	0	0	0.000%

Meiofauna analysis	ST1		Total Per Station	ST2		Total Per Station	ST3		Total Per Station	Total	%
	28-Dec-18	31-Jan-18		28-Dec-18	31-Jan-18		28-Dec-18	31-Jan-18			
Kinorhyncha	0	0	0	0	0	0	0	0	0	0	0.000%
Lancelet	0	0	0	0	0	0	0	0	0	0	0.000%
Nauplii	0	0	0	0	0	0	0	0	0	0	0.000%
Nematoda	420	685	1105	11780	19201	30981	4870	7938	12808	44894	91.725%
Nematomorpha	0	0	0	0	0	0	0	0	0	0	0.000%
Nemertina	0	0	0	0	0	0	0	0	0	0	0.000%
Oligochaeta	0	0	0	0	0	0	0	0	0	0	0.000%
Ostracoda	0	0	0	30	49	79	0	0	0	79	0.161%
Polychaeta	0	0	0	0	0	0	10	16	26	26	0.053%
Rotifera	0	0	0	0	0	0	0	0	0	0	0.000%
Tardigrada	0	0	0	10	16	26	0	0	0	26	0.053%
Turebllaria	0	0	0	0	0	0	0	0	0	0	0.000%
Unknown	0	0	0	0	0	0	0	0	0	0	0.000%
Total	**1130**	**1842**	**2972**	**12130**	**19772**	**31902**	**5350**	**8720**	**14070**	**48944**	


Tardigrada
0.05%
Polychaeta
0.05%
Bivalvia
0.1%
Ciliata
3.4%
Copepoda
0.26%
Ostracoda
0.16%
Foraminifera
4.1%
Nematoda
91.72%
Meiofaunal Taxa Density
Bivalvia
Ciliata
Copepoda
Foraminifera
Nematoda
Ostracoda
Polychaeta
Tardigrada

6.2.9.2 Testing results before, during and after treatment:

A. Tested by third party MEL/Alcontrol:

Seawater testing results "Station No. 1":

Parameter	Limit Tab.1,2	Unit	Station 1						
			18.12.18	31.01.17	13.05.18	11.06.18	25.06.18	16.07.18	12.08.18
Temperature		˚C	19	20	20	21	21	21	21
pH	6.5-8.5		8		8.2	8.2	8.2	8.1	8.14
Biochemical Oxygen Demand (BOD)		mg/L	5		4.8	6.9	4.5	10.8	4.6
Chemical Oxygen Demand (COD)		mg/L	144		32.7	105	44.4	76.2	43.2
Oil & Grease		mg/L	<0.75		<0.75	<0.75	<0.75	<0.75	<0.75
Total Suspended Solids (TSS)	30	mg/L	129		61	14	22	18	18
Total Dissolved Solids (TDS)	33-45	g/L-ppt	44.2		49	47.2	45.3	41.64	41.1
Ammonia as NH3-N	0.06	mg/L	0.5		0.2	0.4	0.26	0.3	0.4
Copper	15	µg/l	<6			<6	<5	8.3	7.9
Lead	12	µg/l	15			<8	<10	<10	<10
Zinc		µg/l	<20			<20	<5	<5	<5

Parameter	Limit Tab.1,2	Unit	Station 1						
			18.12.18	31.01.17	13.05.18	11.06.18	25.06.18	16.07.18	12.08.18
Sulphide (free) (S2-)		mg/l	<0.1			1	0.016	9	6
Yeast & Mold		CFU/ml	40						
Salmonella			absence						
Staphylococcus aureus		CFU/ml	<1						
E-Coli	500	CFU/100 mL	279	150	200	2200	500	1800	210
Total coliforms		CFU/100 mL				3020	1010	2800	400
Fecal coliforms	500	CFU/100 mL		210		2500	530	2100	360
Feacal Streptococci Bacteria	200	CFU/100 mL	<1		50	100	<1	178	35
Heterotropic Plate Count		CFU/mL		320000	1600	260000	140000	1100	9500

Seawater testing results "Station No. 2":

Parameter	Limit Tab.1,2	Unit	Station 2						
			18.12.18	31.01.17	13.05.18	11.06.18	25.06.18	16.07.18	12.08.18
Temperature		˚C	19	20	20	21	21	21	21
pH	6.5-8.5		8		8.2	8.2	8.2	8.1	8.03
Biochemical Oxygen Demand (BOD)		mg/L	6		4.8	11.6	5.7	<4	< 4

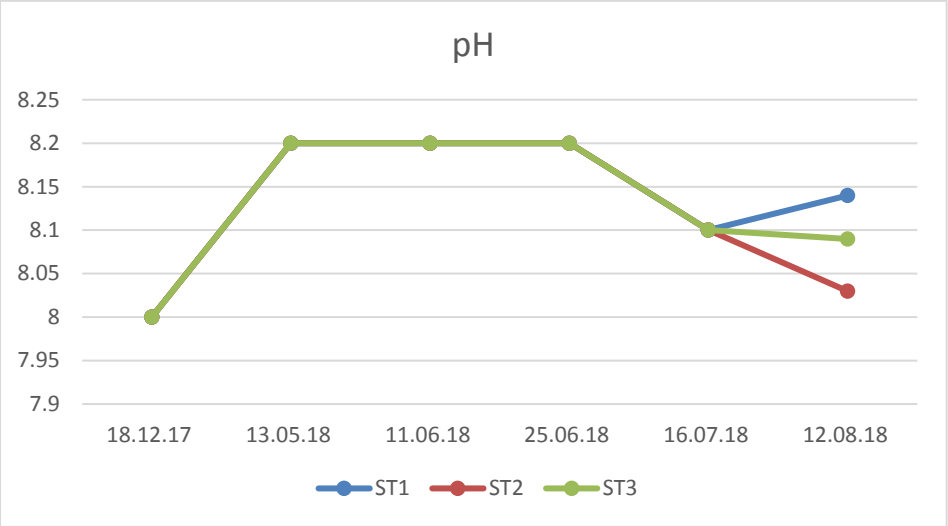
Parameter	Limit Tab.1,2	Unit	Station 2						
			18.12.18	31.01.17	13.05.18	11.06.18	25.06.18	16.07.18	12.08.18
Chemical Oxygen Demand (COD)		mg/L	140		31.6	146	48.2	53.6	33.2
Oil & Grease		mg/L	<0.75		<0.75	<0.75	<0.75	<0.75	<0.75
Total Suspended Solids (TSS)	30	mg/L	109		52	10	18	22	18
Total Dissolved Solids (TDS)	33-45	g/L-ppt	44.2		48.6	43.9	45.8	42.26	42.2
Ammonia as NH3-N	0.06	mg/L	0.4		0.25	0.35	0.21	0.32	0.26
Copper	15	µg/l	<6			<6	<5	8.8	8.1
Lead	12	µg/l	17			<8	<10	<10	<10
Zinc		µg/l	<20			<20	6.1	<5	7.2
Sulphide (free) (S2-)		mg/l	<0.1			4	0.015	18	11
Yeast & Mold		CFU/ml	20						
Salmonella			absence						
Staphylococcus aureus		CFU/ml	<1						
Total coliforms		CFU/100 mL				4570	3550	1100	550

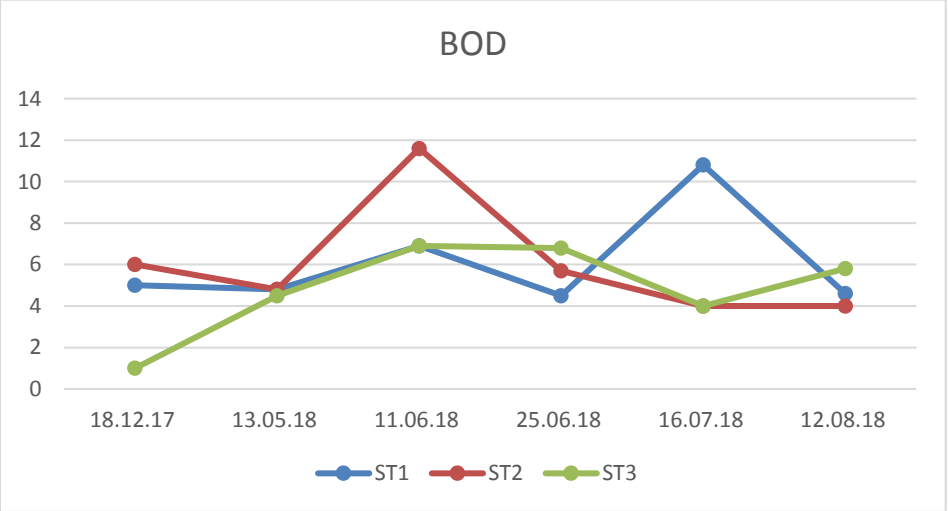
Parameter	Limit Tab.1,2	Unit	Station 2						
			18.12.18	31.01.17	13.05.18	11.06.18	25.06.18	16.07.18	12.08.18
Fecal coliforms	500	CFU/100 mL		TNTC		4020	2200	850	220
Feacal Streptococci Bacteria	200	CFU/100 mL	<1		20	700	103	102	25
Heterotropic Plate Count		CFU/mL		360000	980	85000	300000	100000	14000

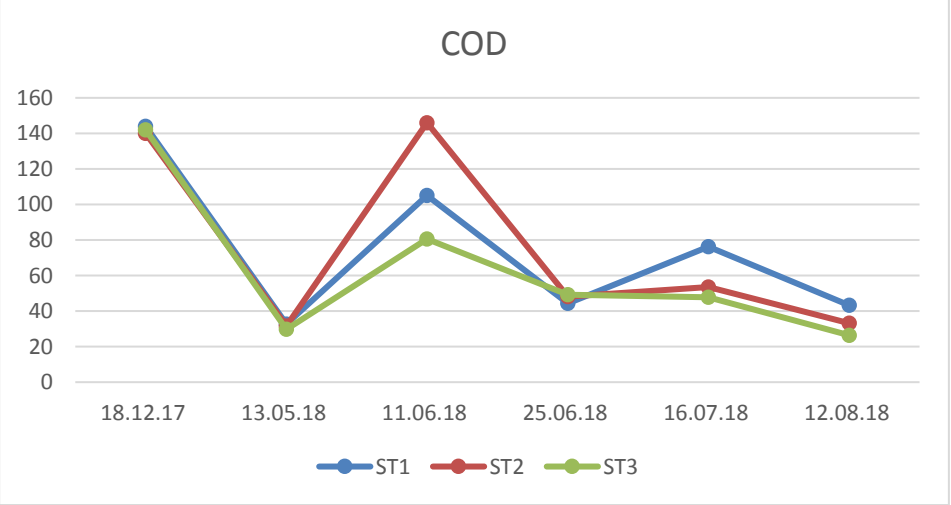
Seawater testing results "Station No. 3":

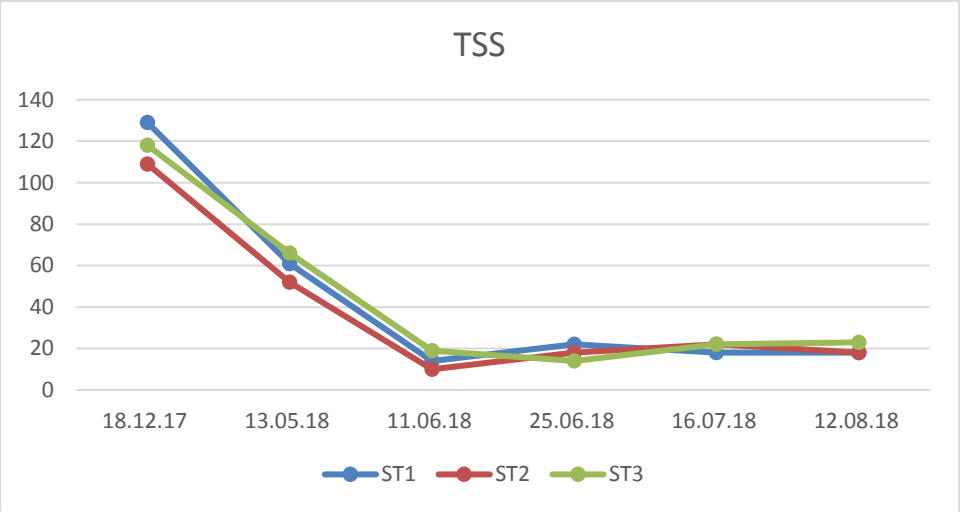
Parameter	Limit Tab.1,2	Unit	Station 3						
			18.12.18	31.01.17	13.05.18	11.06.18	25.06.18	16.07.18	12.08.18
Temperature		˚C	19	20	20	21	21	21	21
pH	6.5-8.5		8		8.2	8.2	8.2	8.1	8.03
Biochemical Oxygen Demand (BOD)		mg/L	6		4.8	11.6	5.7	<4	< 4
Chemical Oxygen Demand (COD)		mg/L	140		31.6	146	48.2	53.6	33.2
Oil & Grease		mg/L	<0.75		<0.75	<0.75	<0.75	<0.75	<0.75
Total Suspended Solids (TSS)	30	mg/L	109		52	10	18	22	18
Total Dissolved Solids (TDS)	33-45	g/L-ppt	44.2		48.6	43.9	45.8	42.26	42.2
Ammonia as NH3-N	0.06	mg/L	0.4		0.25	0.35	0.21	0.32	0.26

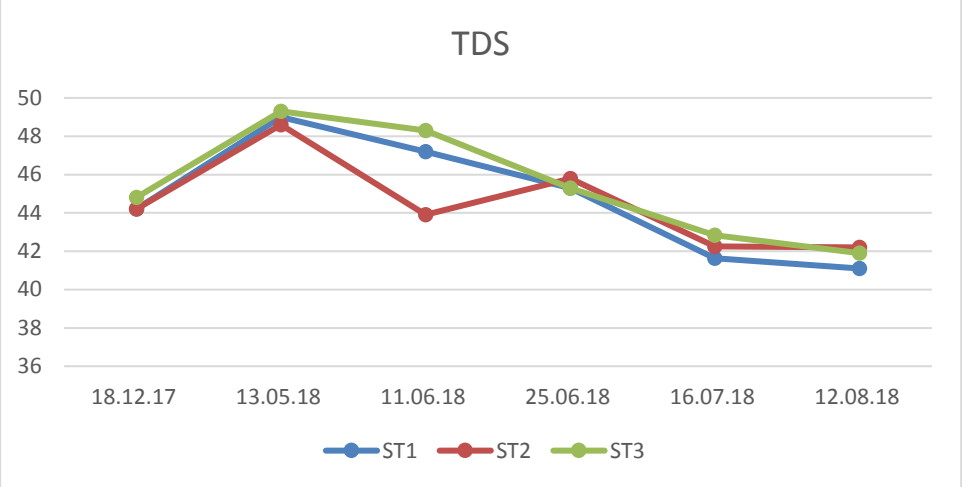
Parameter	Limit Tab.1,2	Unit	Station 3						
			18.12.18	31.01.17	13.05.18	11.06.18	25.06.18	16.07.18	12.08.18
Copper	15	µg/l	<6			<6	<5	8.8	8.1
Lead	12	µg/l	17			<8	<10	<10	<10
Zinc		µg/l	<20			<20	6.1	<5	7.2
Sulphide (free) (S2-)		mg/l	<0.1			4	0.015	18	11
Yeast & Mold		CFU/ml	20						
Salmonella			absence						
Staphylococcus aureus		CFU/ml	<1						
E-Coli	500	CFU/100 mL	150	309	210	3700	2200	650	190
Total coliforms		CFU/100 mL				4570	3550	1100	550
Fecal coliforms	500	CFU/100 mL		TNTC		4020	2200	850	220
Feacal Streptococci Bacteria	200	CFU/100 mL	<1		20	700	103	102	25
Heterotropic Plate Count		CFU/mL		360000	980	85000	300000	100000	14000

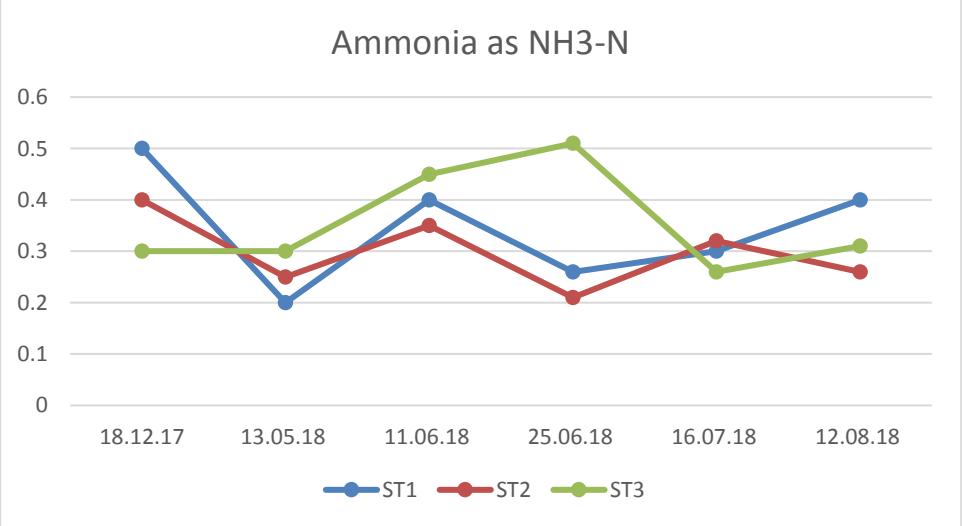

pH
8.25
8.2
8.15
8.1
8.05
8
7.95
7.9
18.12.17
13.05.18
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3

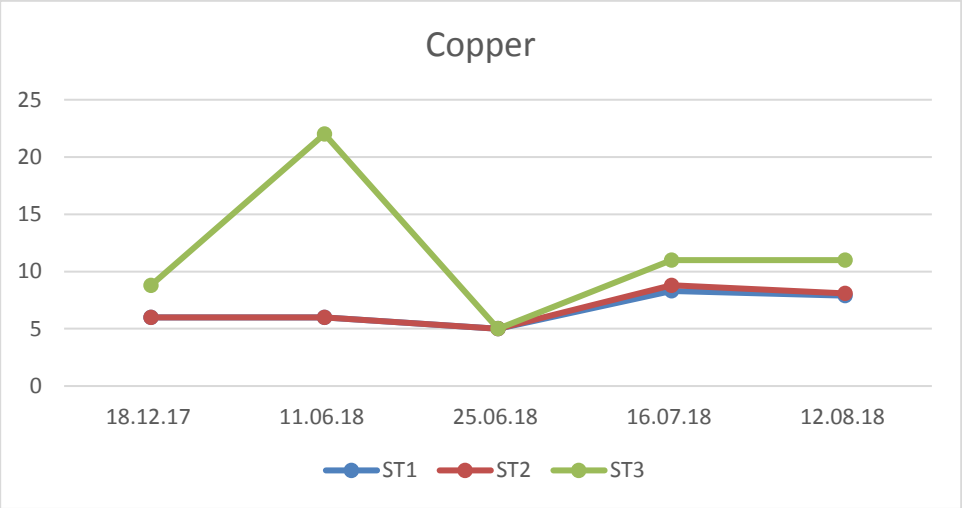

BOD
14
12
10
8
6
4
2
0
18.12.17
13.05.18
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3

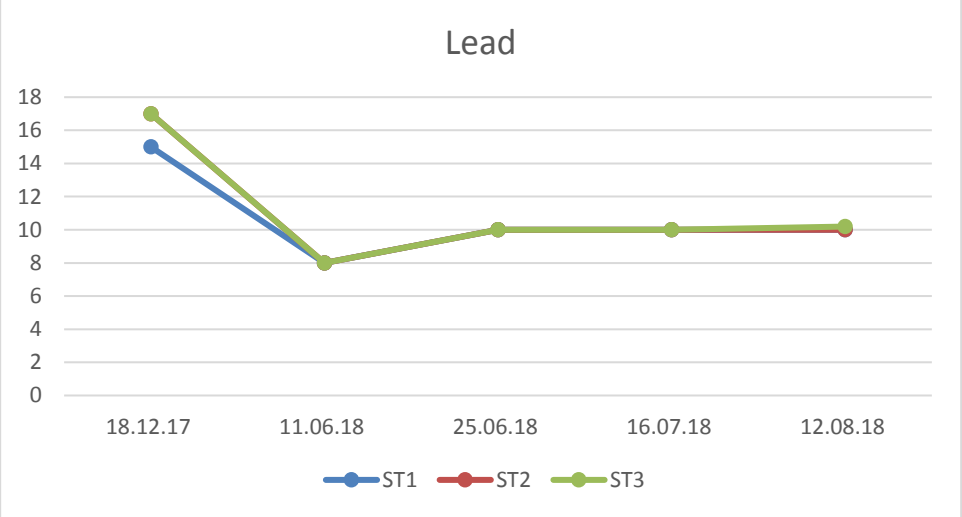

COD
160
140
120
100
80
60
40
20
0
18.12.17
13.05.18
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3

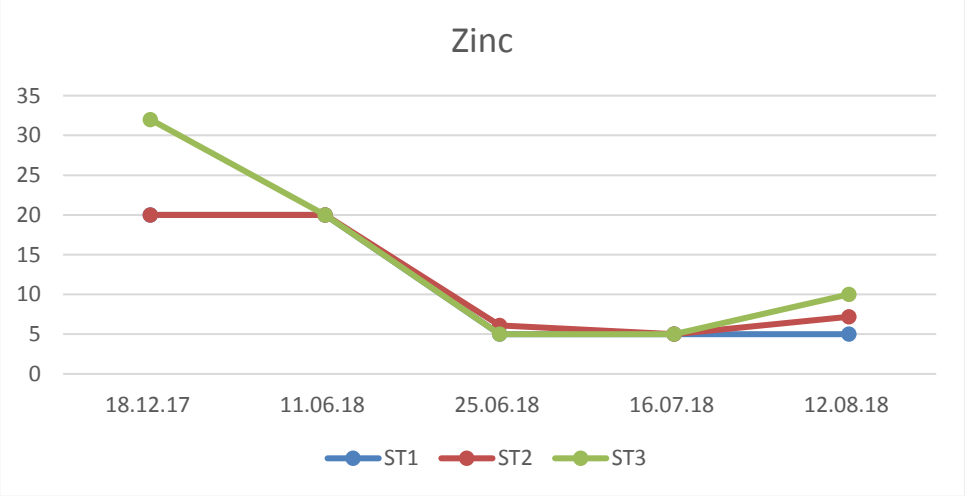

TSS
140
120
100
80
60
40
20
0
18.12.17
13.05.18
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3

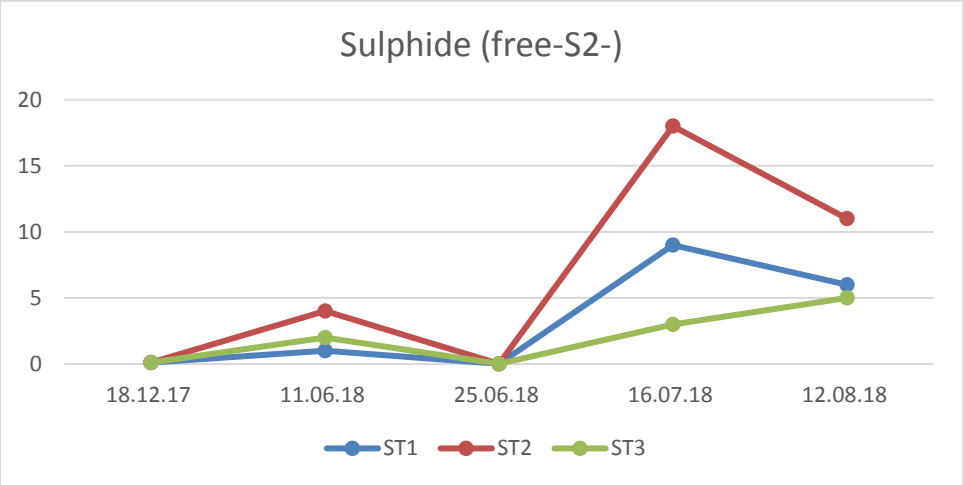

TDS
50
48
46
44
42
40
38
36
18.12.17
13.05.18
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3

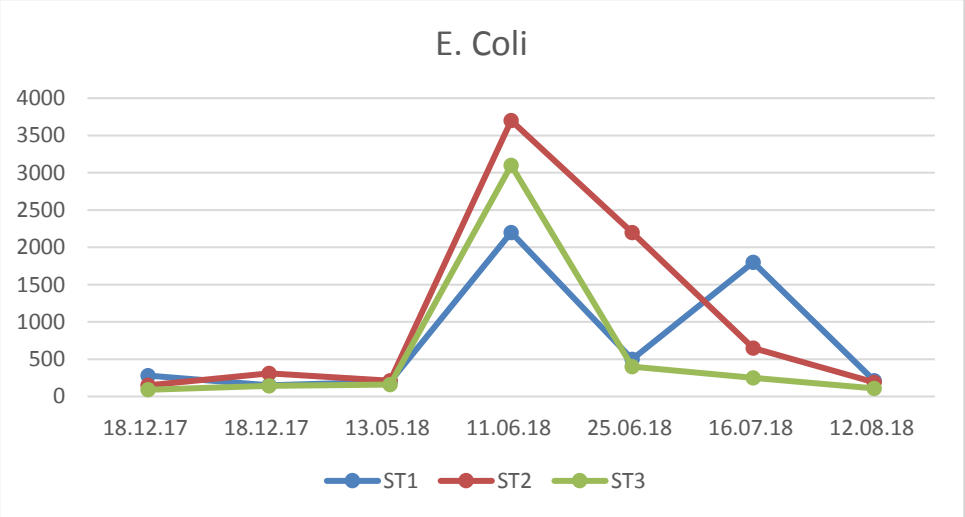

Ammonia as NH3-N
0.6
0.5
0.4
0.3
0.2
0.1
0
18.12.17
13.05.18
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3

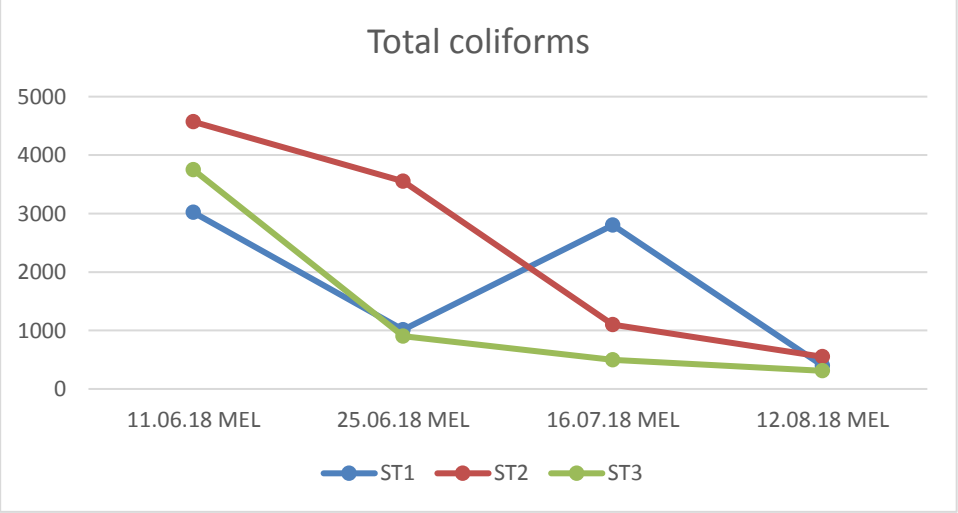

Copper
25
20
15
10
5
0
18.12.17
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3

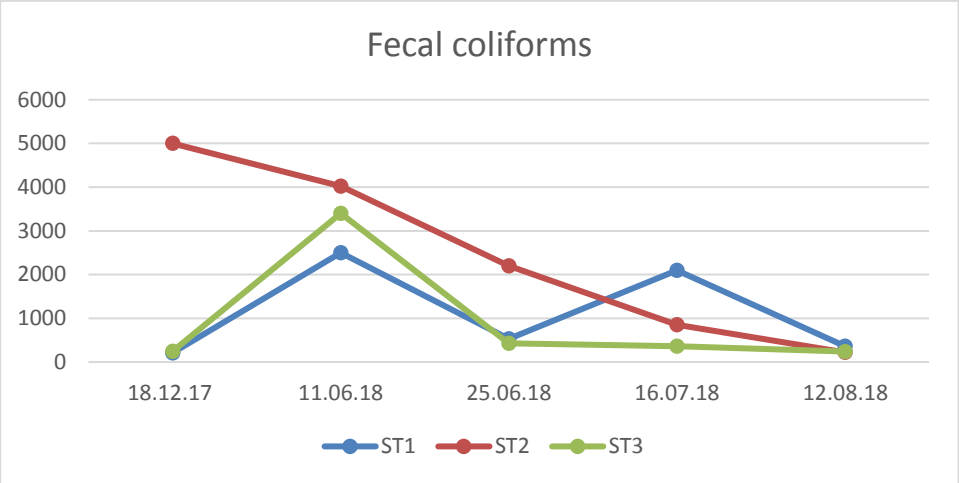

Lead
18
16
14
12
10
8
6
4
2
0
18.12.17
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3

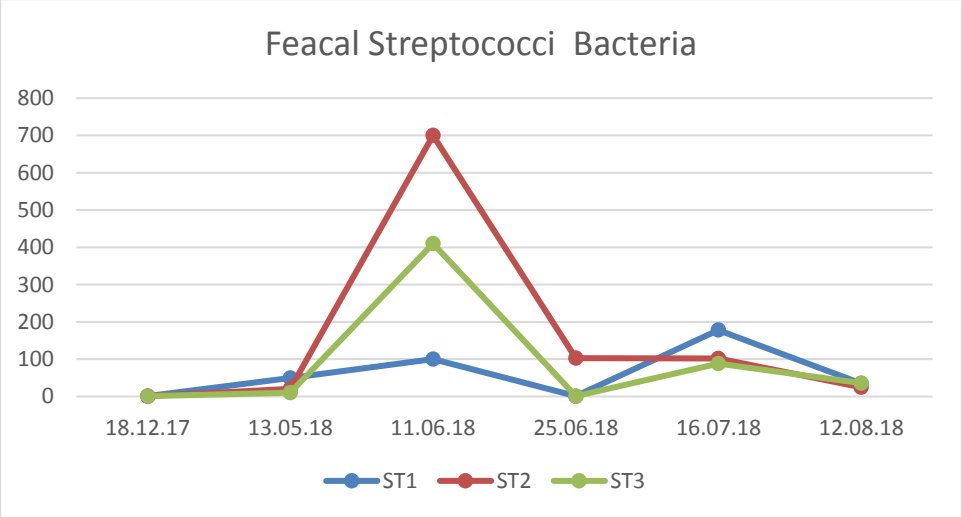

Zinc
35
30
25
20
15
10
5
0
18.12.17
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3

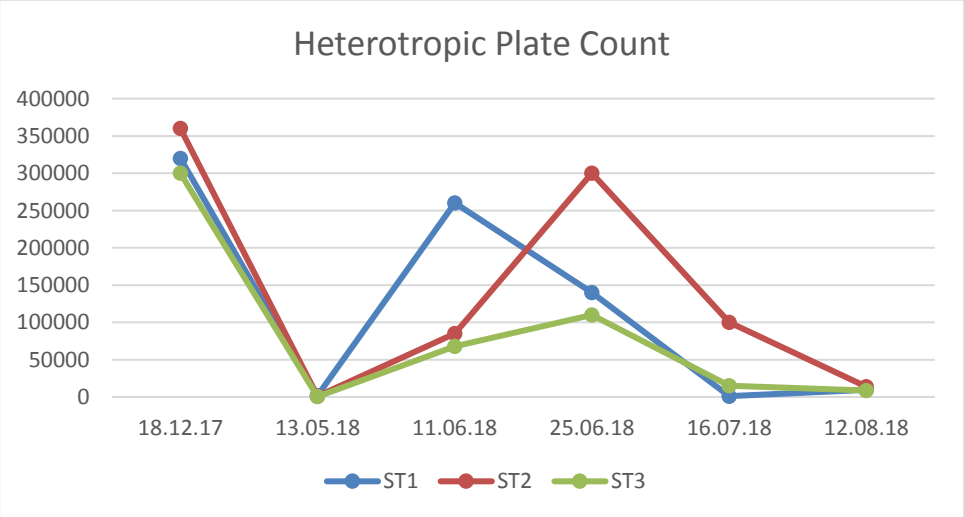

Sulphide (free-S2-)
20
15
10
5
0
18.12.17
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3


E. Coli
4000
3500
3000
2500
2000
1500
1000
500
0
18.12.17
18.12.17
13.05.18
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3


Total coliforms
5000
4000
3000
2000
1000
0
11.06.18 MEL
25.06.18 MEL
16.07.18 MEL
12.08.18 MEL
ST1
ST2
ST3


Fecal coliforms
6000
5000
4000
3000
2000
1000
0
18.12.17
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3


Feacal Streptococci Bacteria
800
700
600
500
400
300
200
100
0
18.12.17
13.05.18
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3

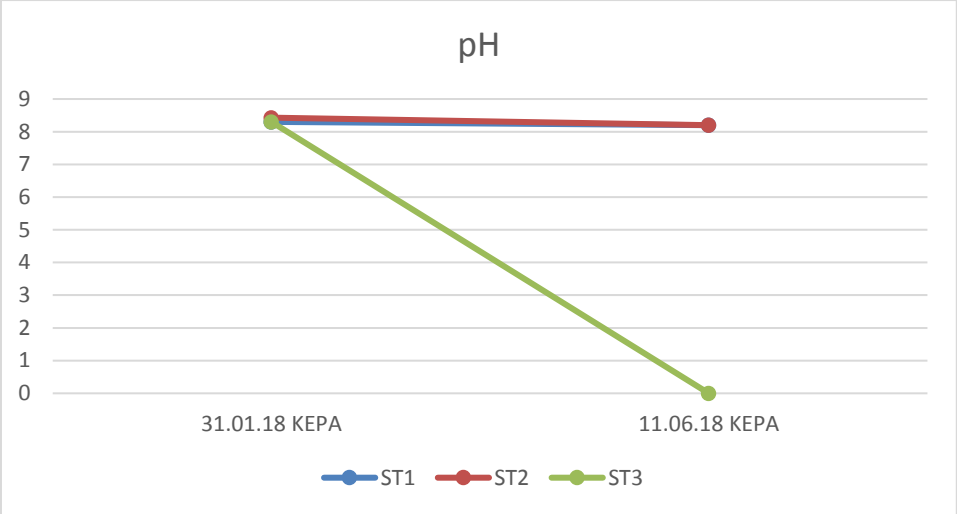

Heterotropic Plate Count
400000
350000
300000
250000
200000
150000
100000
50000
0
18.12.17
13.05.18
11.06.18
25.06.18
16.07.18
12.08.18
ST1
ST2
ST3

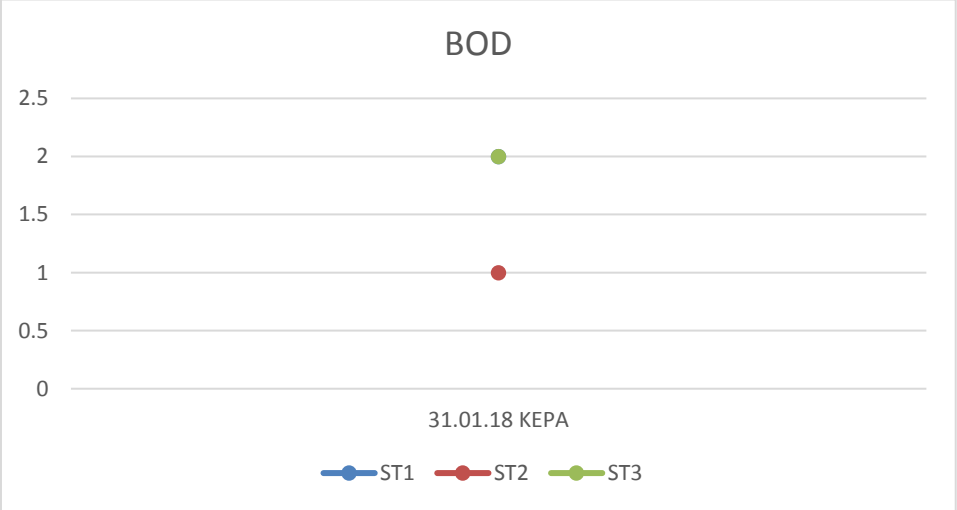
B. Tested by KEPA LAB:

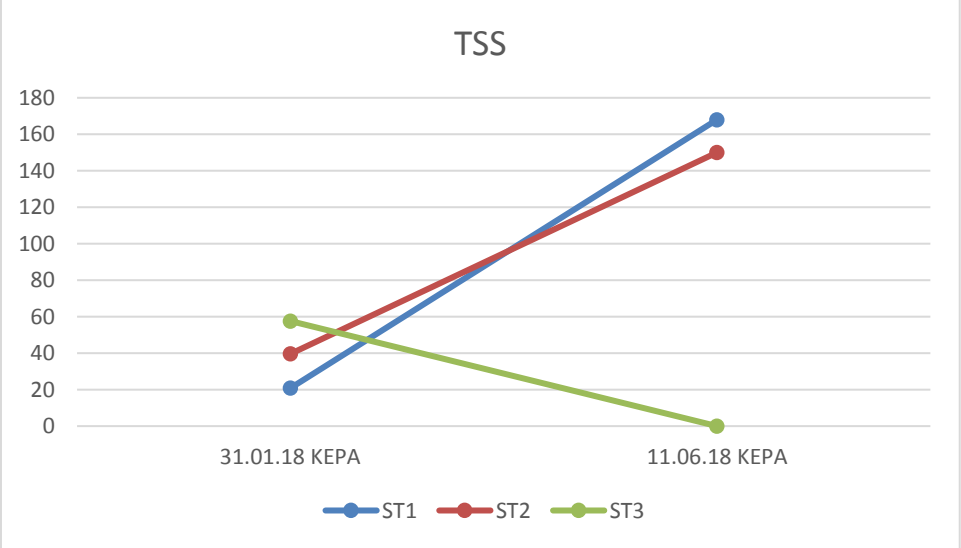
Seawater testing results "Stations No. 1, 2 & 3":

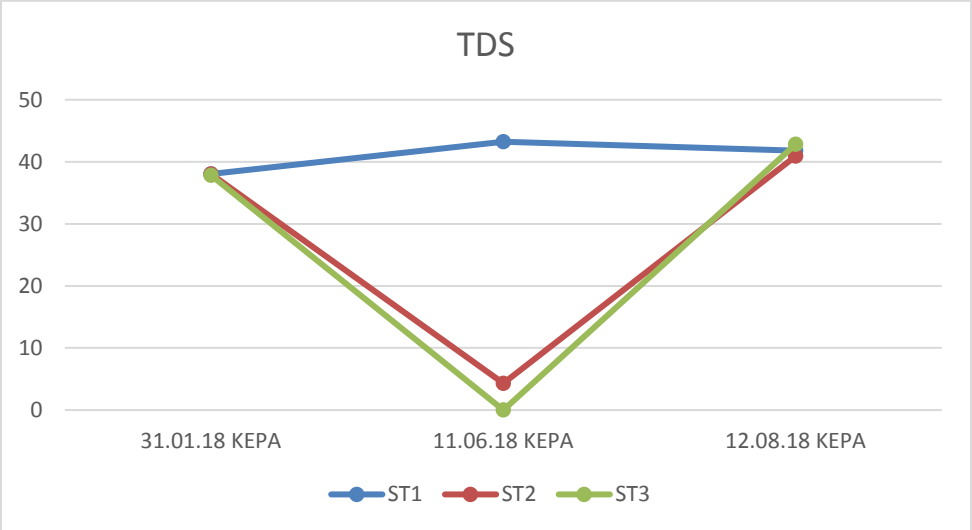
Parameter	Limit App. 1,2	Unit	Station 1			Station 2			Station 3		
			31.01.18 KEPA	11.06.18 KEPA	12.08.18 KEPA	31.01.18 KEPA	11.06.18 KEPA	12.08.18 KEPA	31.01.18 KEPA	11.06.18 KEPA	12.08.18 KEPA
pH	6.5-8.5		8.3	8.02	--	8.43	8.02	--	8.3	--	--
Biochemical Oxygen Demand (BOD)		mg/L	2	--	--	1	--	--	2	--	--
Total Suspended Solids (TSS)	30	mg/L	20.8	168	--	39.6	150	--	57.6	--	--
Total Dissolved Solids (TDS)	33-45	g/L-ppt	38.04	43.23	41.78	38.02	4.31	40.9	37.8	--	42.81
Ammonia as NH3-N	0.06	mg/L	0.02752	0.195	0.1	0.02262	0.0088	0.02	0.02242	--	0.1
Copper	15	µg/l	0.3133	--	--	0.311	--	--	0.1338	--	--
Lead	12	µg/l	0.0243	--	--	0.061	--	--	0.0521	--	--
Iron	90	µg/l	1.123	--	--	1.106	--	--	0.602	--	--
Nickel	20	µg/l	2.262	--	--	0.935	--	--	0.0788	--	--
Cadmium	0.7	µg/l	0.0039	--	--	0.015	--	--	0.0018	--	--
Vanadium	9	µg/l	0.0963	--	--	0.038	--	--	0.0378	--	--
Chlorophyll		mg/m3	1.95	0.095	--	3.55	0.077	--	1.166	--	--

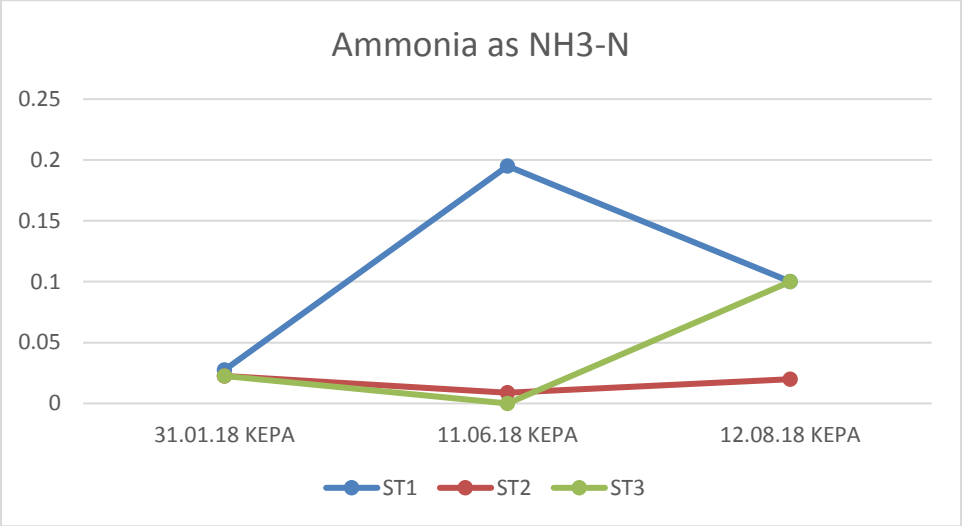
Parameter	Limit App. 1,2	Unit	Station 1			Station 2			Station 3		
			31.01.18 KEPA	11.06.18 KEPA	12.08.18 KEPA	31.01.18 KEPA	11.06.18 KEPA	12.08.18 KEPA	31.01.18 KEPA	11.06.18 KEPA	12.08.18 KEPA
TOC	5	mg/L	2.45	--	1.833	3.765	--	--	2.633	--	--
Phosphate (PO4-P)	34	µg/l	70.39	97.23	0.04	47.32	135.83	0.04	37.79	--	0.03
Nitrate (NO_3-N)	95	µg/l	24.429	42.39	0	23.224	53.34	0	22.1	--	0
Nitrite (NO_2-N)	35	µg/l	2.64	4.68	--	3.96	8.89	--	3.43	--	--
Silicate (SiO_3-Si)	900	µg/l	742.68	273	399	974.4	294.85	323	826.52	--	330
E-Coli	500	CFU/100 mL	1560	--	180	1470	--	60	1640	--	160
Fecal coliforms	500	CFU/100 mL	1560	--	180	1470	--	60	1780	--	160
Feacal Streptococci Bacteria	200	CFU/100 mL	40	--	130	210	--	60	80	--	40

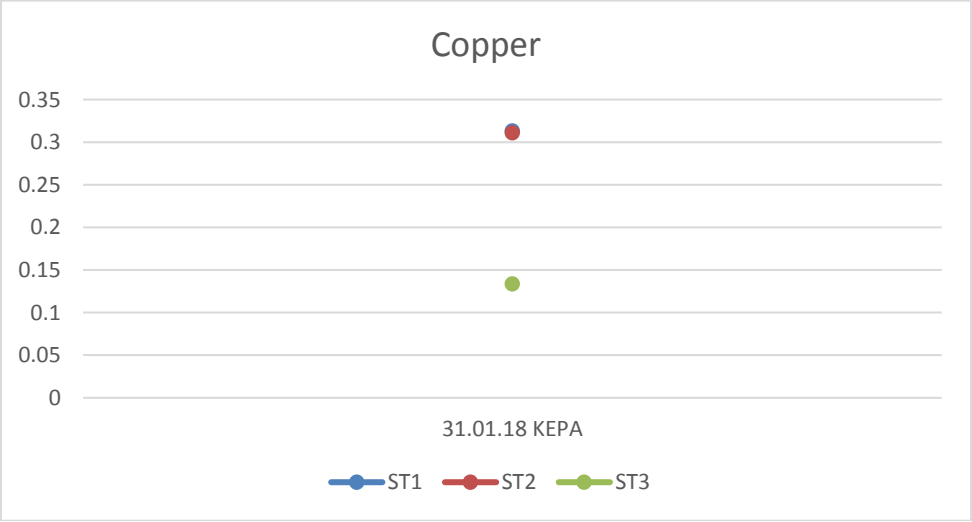

pH
9
8
7
6
5
4
3
2
1
0
31.01.18 KEPA
11.06.18 KEPA
ST1
ST2
ST3

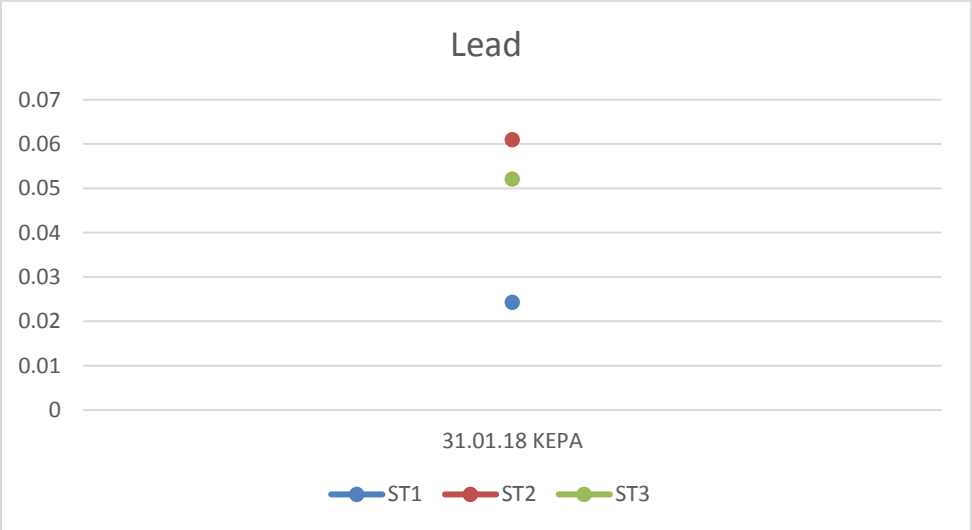

BOD
2.5
2
1.5
1
0.5
0
31.01.18 KEPA
ST1
ST2
ST3

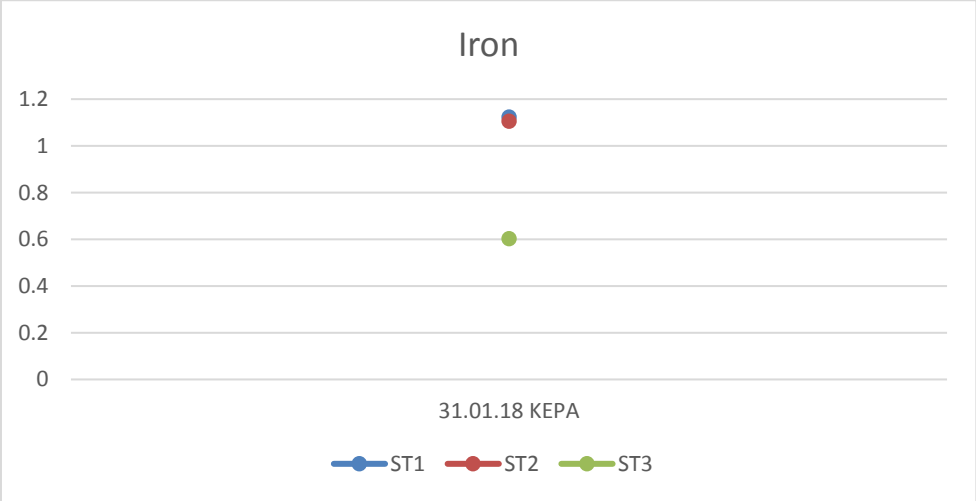

TSS
180
160
140
120
100
80
60
40
20
0
31.01.18 KEPA
11.06.18 KEPA
ST1
ST2
ST3

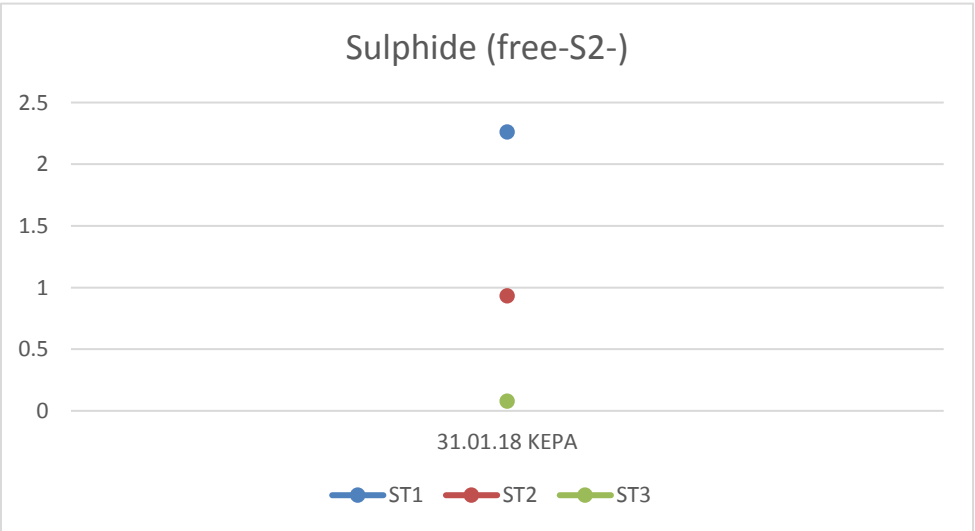

TDS
50
40
30
20
10
0
31.01.18 KEPA
11.06.18 KEPA
12.08.18 KEPA
ST1
ST2
ST3

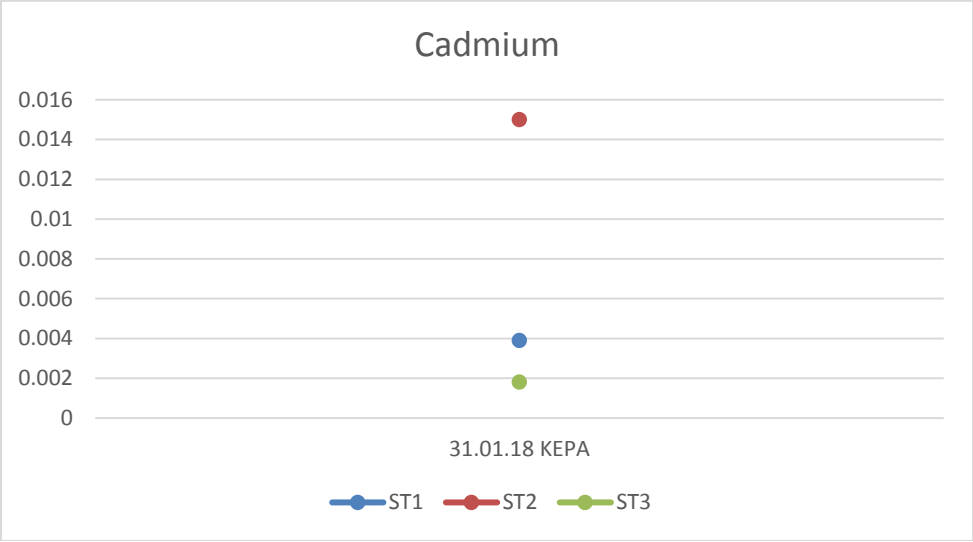

Ammonia as NH3-N
0.25
0.2
0.15
0.1
0.05
0
31.01.18 KEPA
11.06.18 KEPA
12.08.18 KEPA
ST1
ST2
ST3

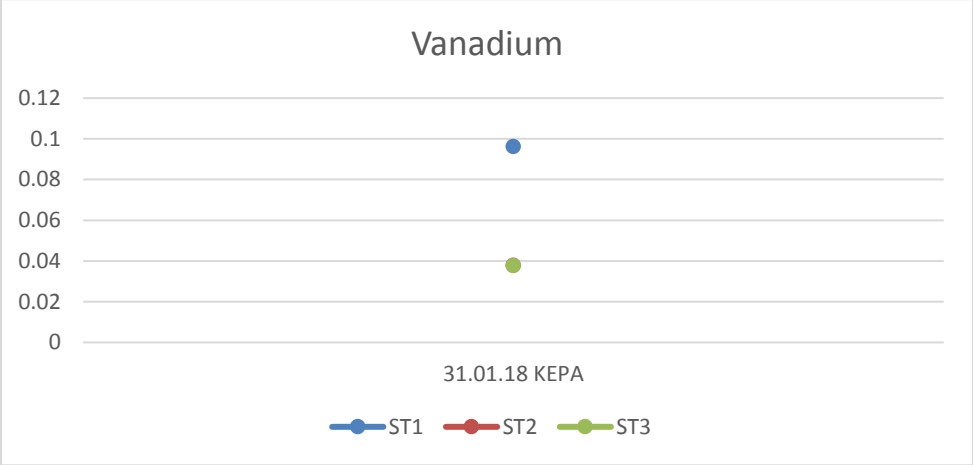

Copper
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
31.01.18 KEPA
ST1
ST2
ST3

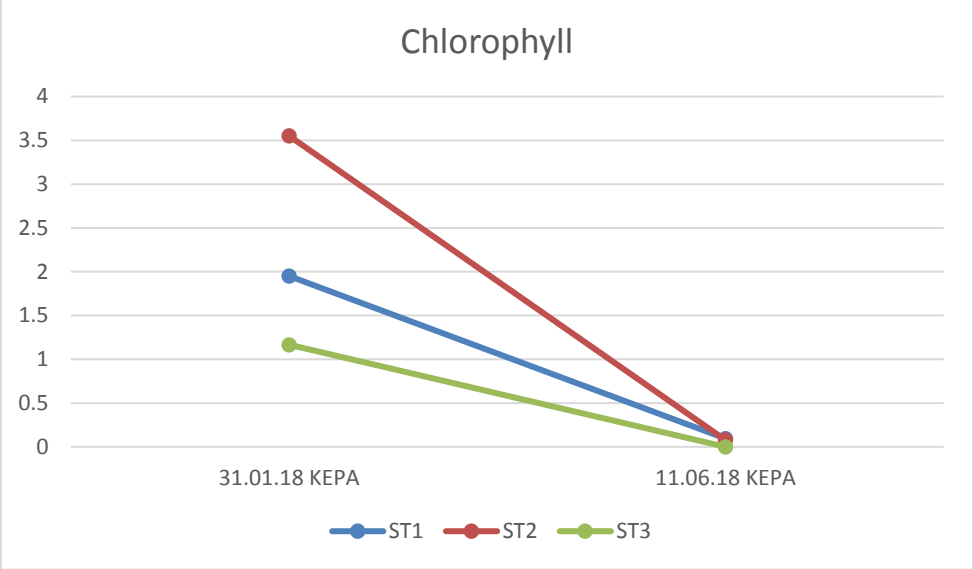

Lead
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
31.01.18 KEPA
ST1
ST2
ST3

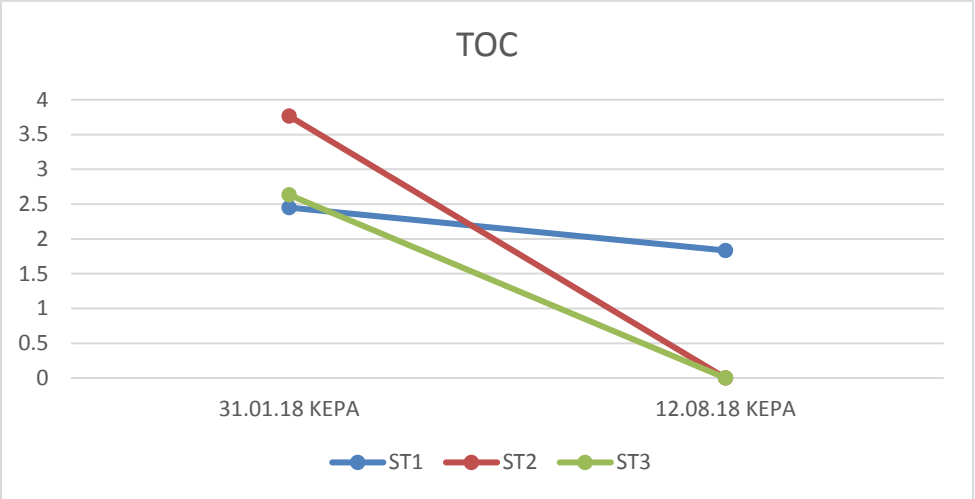

Iron
1.2
1
0.8
0.6
0.4
0.2
0
31.01.18 KEPA
ST1
ST2
ST3

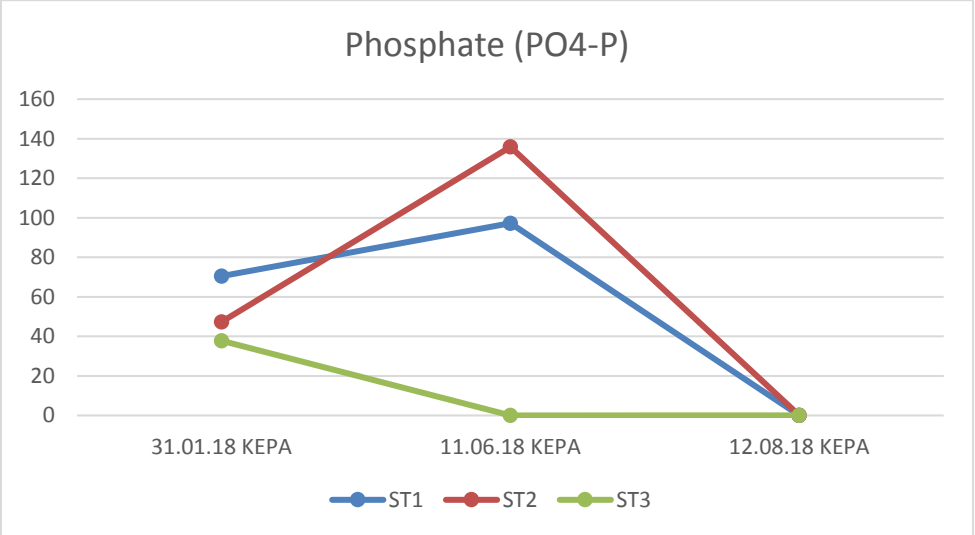

Sulphide (free-S2-)
2.5
2
1.5
1
0.5
0
31.01.18 KEPA
ST1
ST2
ST3

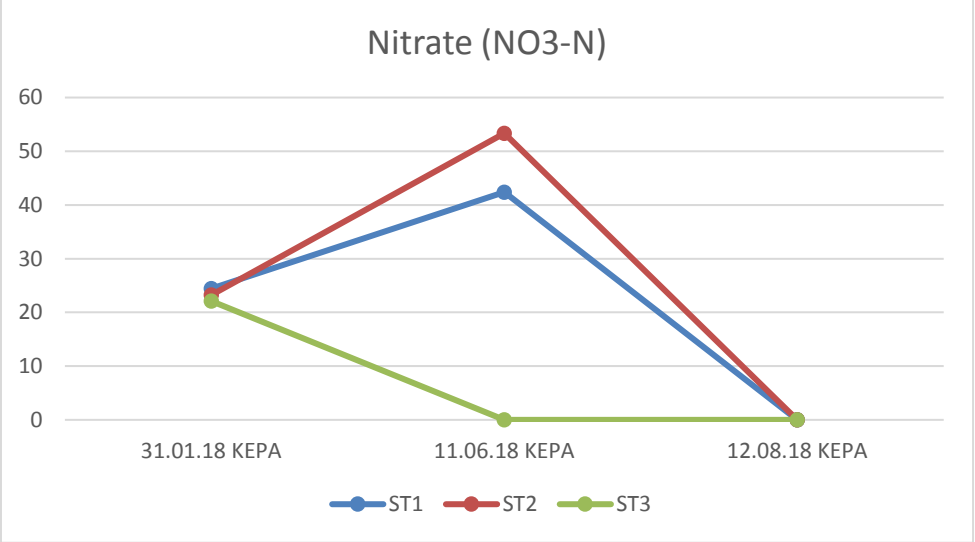

Cadmium
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
31.01.18 KEPA
ST1
ST2
ST3

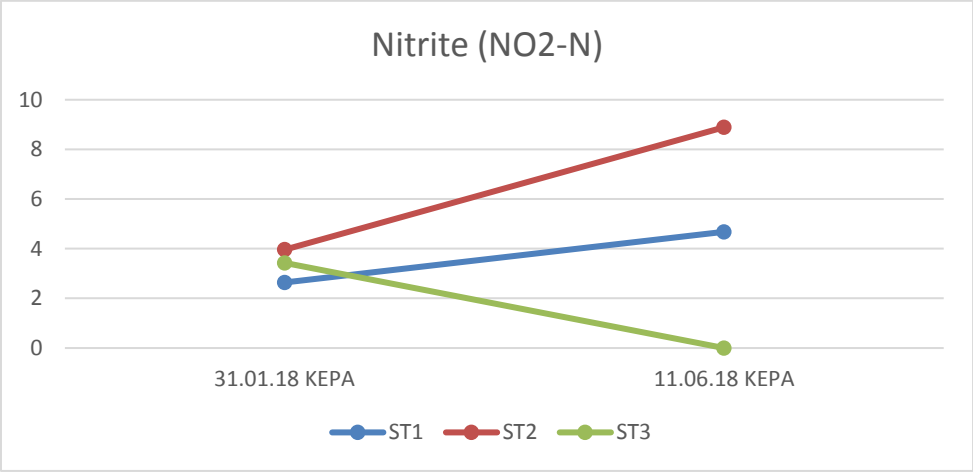

Vanadium
0.12
0.1
0.08
0.06
0.04
0.02
0
31.01.18 KEPA
ST1
ST2
ST3

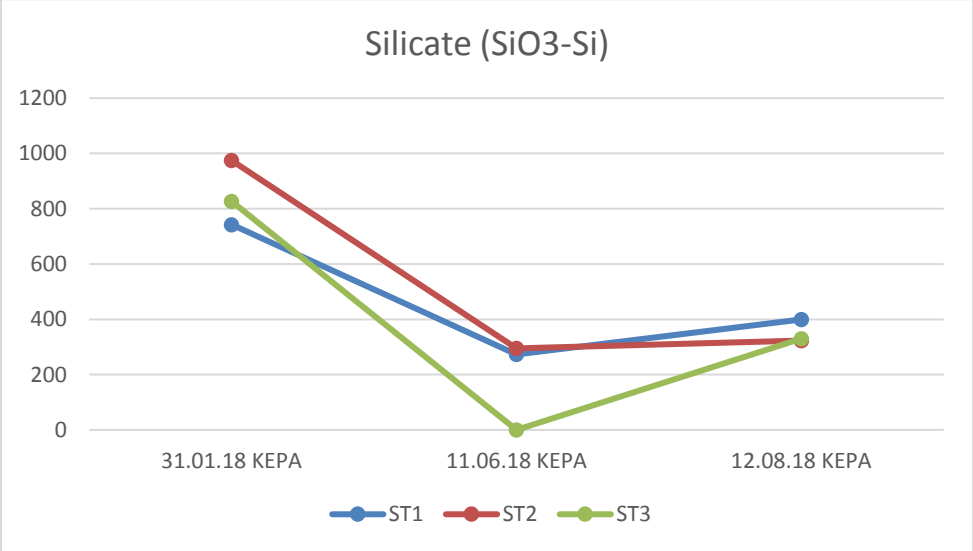

Chlorophyll
4
3.5
3
2.5
2
1.5
1
0.5
0
31.01.18 KEPA
11.06.18 KEPA
ST1
ST2
ST3

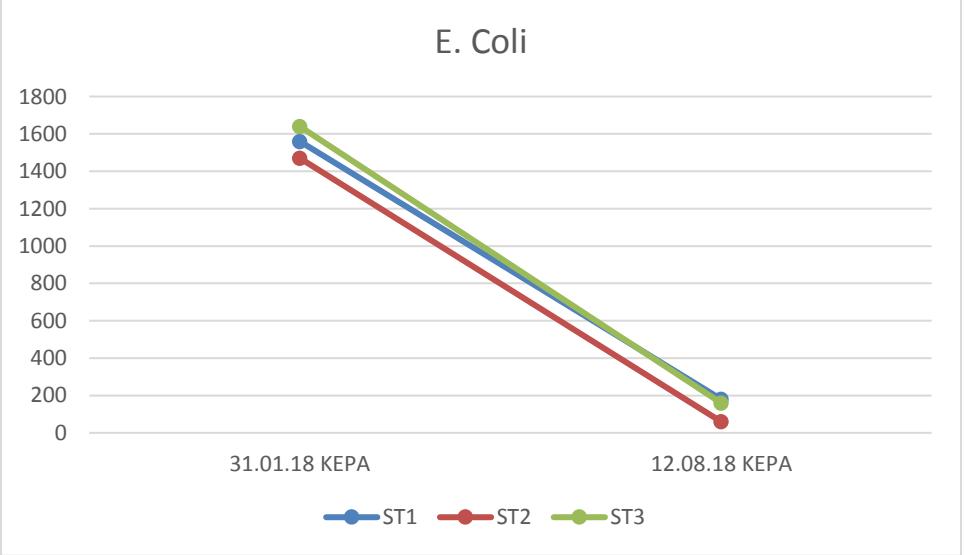

TOC
4
3.5
3
2.5
2
1.5
1
0.5
0
31.01.18 KEPA
12.08.18 KEPA
ST1
ST2
ST3

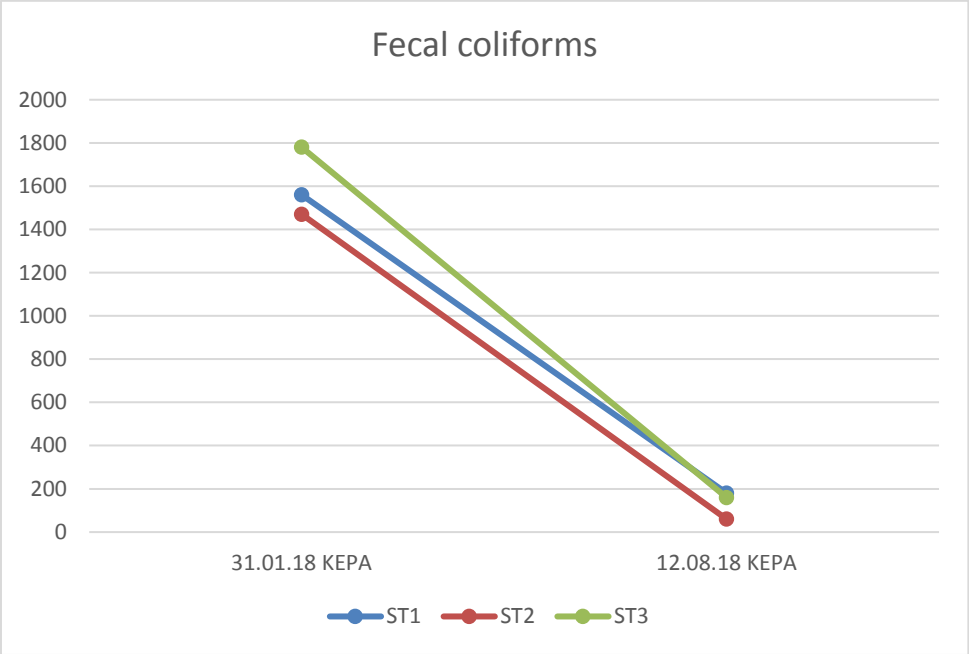

Phosphate (PO4-P)
160
140
120
100
80
60
40
20
0
31.01.18 KEPA
11.06.18 KEPA
12.08.18 KEPA
ST1
ST2
ST3

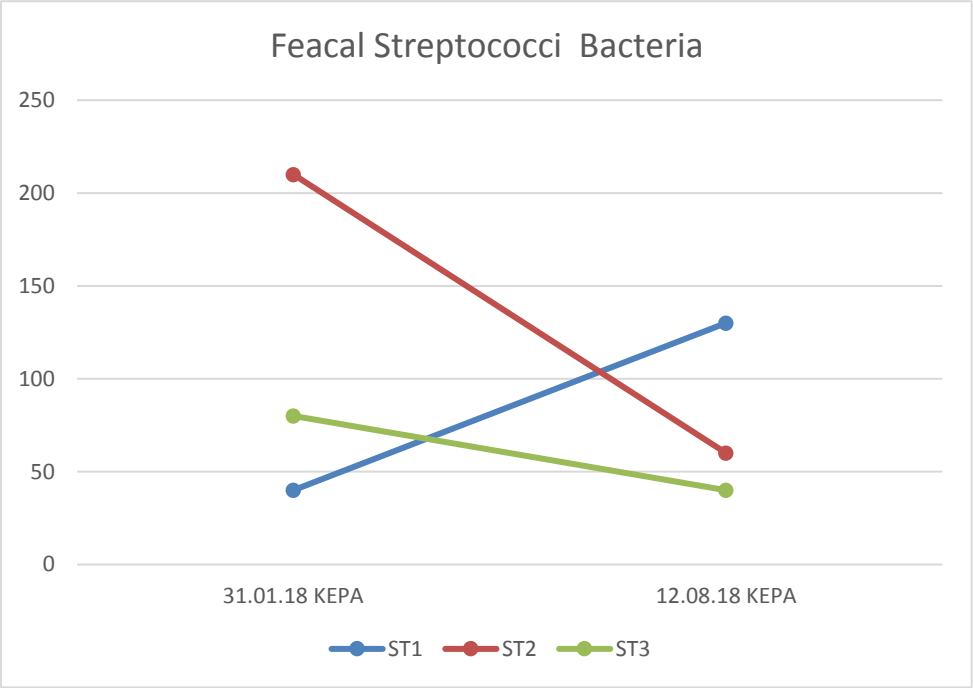

Nitrate (NO3-N)
60
50
40
30
20
10
0
31.01.18 KEPA
11.06.18 KEPA
12.08.18 KEPA
ST1
ST2
ST3


Nitrite (NO2-N)
10
8
6
4
2
0
31.01.18 KEPA
11.06.18 KEPA
ST1
ST2
ST3


Silicate (SiO3-Si)
1200
1000
800
600
400
200
0
31.01.18 KEPA
11.06.18 KEPA
12.08.18 KEPA
ST1
ST2
ST3


E. Coli
1800
1600
1400
1200
1000
800
600
400
200
0
31.01.18 KEPA
12.08.18 KEPA
ST1
ST2
ST3


Fecal coliforms
2000
1800
1600
1400
1200
1000
800
600
400
200
0
31.01.18 KEPA
12.08.18 KEPA
ST1
ST2
ST3


Feacal Streptococci Bacteria
250
200
150
100
50
0
31.01.18 KEPA
12.08.18 KEPA
ST1
ST2
ST3

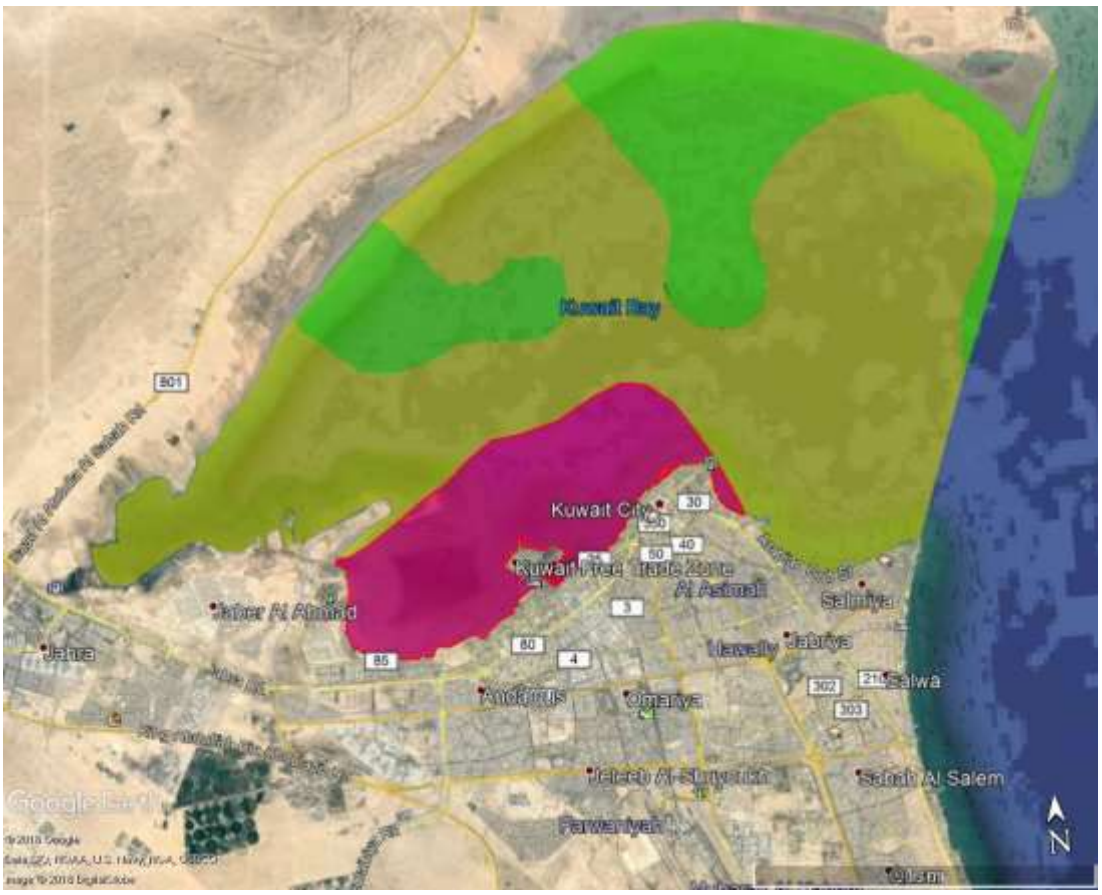
Large-Scale Project Highly Contaminated Area "Red Zone" Treatment Protocol (Sulibkhat Bay & Costal Area Up To Ras Al-Ard Salmiya) Full Project Plan:

Total Contaminated area:

As per DO zoning map:

Sr.	Area	Do Concentration	Total Area	Average Depth (m)	Total average volume*
1	A	Low	110 km²	5	110000000×5= **550,000,000 m³**
2	B	Moderate	455 km²	7	455000000×7= **3,185,000,000 m³**
3	C	Normal	184 km²	10	184000000×10= **1,840,000,000 m³**

* Depth used in volume calculation is average water depth.



The proposal main goal is to increase the DO concentration (using Nano Bubbles) to help the indigenous microorganisms (using Ergofito products) to digest and remediate the contaminated sludge in the effective area, this should be establish as per below recommendations:

1- Intensive remediation using 65 Nano bubbler units (as intensive start-up) including Submersible and non-submersible units and ERGOFITO remediation products (Bioflush & Micromix Aqua), use Nano-bubbles submersible units to be attached with Doha Link Bridge & Jaber Causeway pills presences in the infected area, which will be able to feed Sulibkhat bay with Oxygen during high tide and rest of costal line during low tide timing.

2- Upstream treatment including fixing Nano bubble units in the storm water network to insure WW to be treated before reaching the seaside. If MPW approved it might be better to either replace existing aeration system with Nano bubbles and adding EGROFITO products in MPW sewage treatment plant, which is connected with storm water network, also to monitor the drainage pipes, which have heavy discharge and not connected to MPW STPs and fix Nano-bubbles submersible units and ERGOFITO dosing system inside storm water manholes.

3- Extra Nano bubbles to be used in location, which secure water presence all daytime (ex. Shuwaikh port, Sharq boat anchorage, Marina boat anchorage).

4- Suggestion to fix submersible & Non- submersible units in Doha and Subyia Power stations which should improve cooling system performance and reduce/eliminate amount of chemicals used for anti-scalant and anti-fouling.

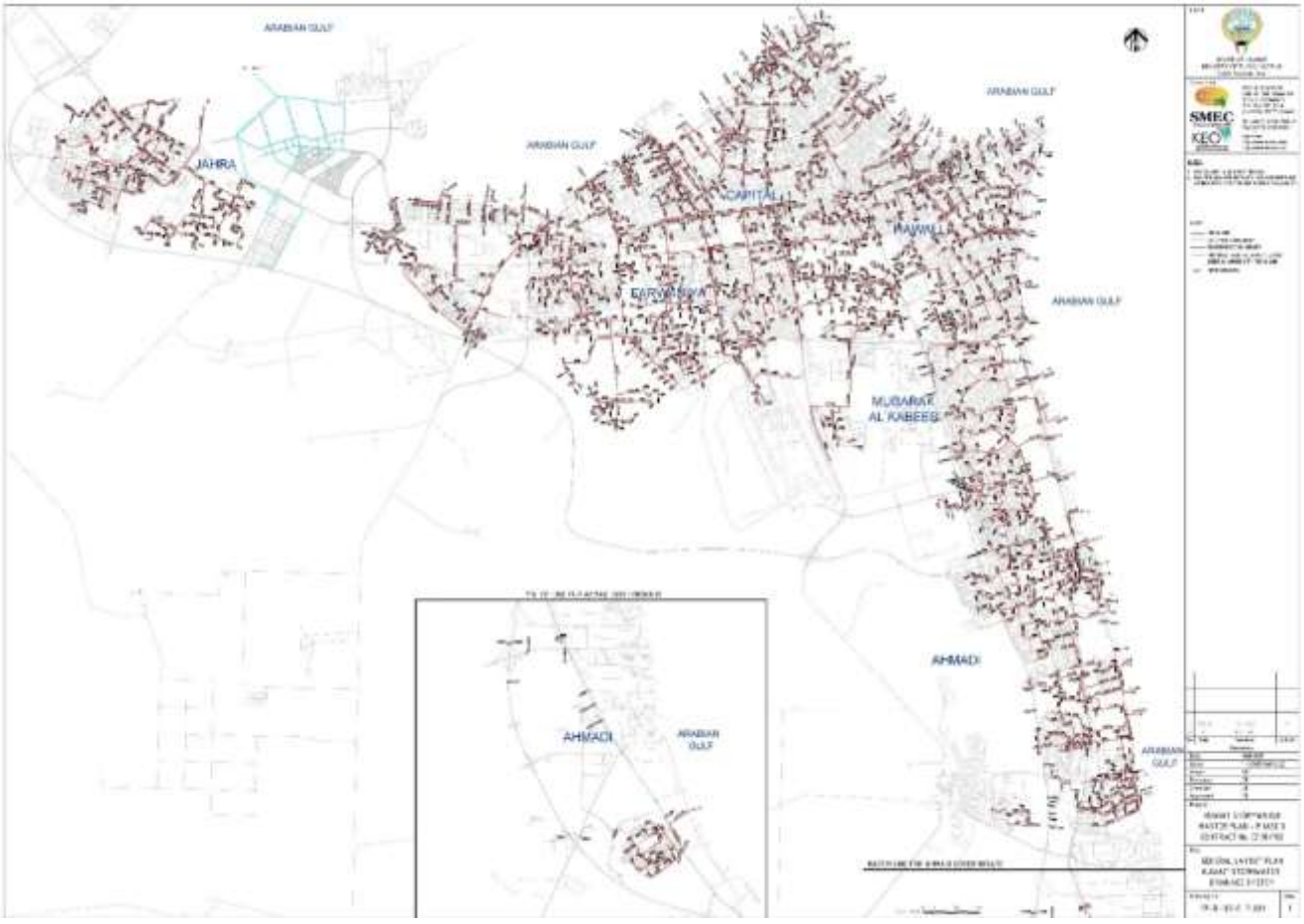
5- Live Monitoring/Controlling system to observe all units working condition and control DO concentrations to avoid over saturation.

6- Using fixed Automatic mixing/dosing system for on-shore treatment location to feed ERGOFITO products. Also using special boat equipped with built-in tanks for mixing the Bio products with seawater and spray it using water guns to cover off-shore areas.

7- Maintained plan should be stablish to maintain all mechanical equipment.

8- Install live monitoring devices in the hot spot areas, which usually have heavy illegal discharge. Emergency response plan should be stablish in case of any sudden discharge in order to reduce the bad impact on the Bay.

9- Involve Kuwaiti Local Authorities to execute the above plan is KEPA, MPW, MEW, Oil companies and coastal guard.



Recommendations:

- It is imperative to stop whatever polluted the body of water in the first place.
- Whatever the discharge is, we need to treat that inflow first to ensure sustained remediation.
- It necessary to collect all floating debris regularly.
- If aeration and ErgoFito is applied to remediate the bay, the sea floor can be fully restored by regular application post ErgoFito application. All foreign objects on the Bay floor should be removed to speed up ecological recovery.