CIN : U45200TG2006PLC049668

HETERO INFRASTRUCTURE SEZ LTD.

Ch. Lakshmipuram (Vill.), N. Narasapuram (Vill.), Rajayyapeta (Vill.), Nakkapally (Mandal)
VISAKHAPATNAM (Dist.) - 531 081. A.P., India. Tel : 08931- 227307, Fax : 08931- 227200
E-mail : contact@heterodrugs.com. URL : http//www.heterodrugs.com.

25h January 2022

Letter No: HIS/EHS/MoEF/2021-22/02

The Director (S)
Regional Office (South Eastern Region)
Ministry of Environment Forest and Climate Change
1st and 2nd Floor, HEPC Building
No:34, Cathedral Garden Road
Nungambakkam
Chennai-600034

Dear Sir,

Sub : Submission of six monthly compliance report of Environmental Clearance issued to M/s Hetero Infrastructure SEZ Ltd, Nakkapalli, Visakhapatnam – Certified by third party -Regarding

Ref : Environmental Clearance No: 21-641/2007-IA, III (I) Dated 25/10/2010

With reference to the above, please find enclosed six monthly compliance report of Environmental clearance of M/s Hetero Infrastructure SEZ Ltd, certified by third party approved by MoEF&CC (NABL & NABET Accredited Lab) for the period July 2021 to December 2021 with all necessary attachments for your kind information and perusal.

Kindly acknowledge the receipt.

Thanking you,

Yours faithfully,
For Hetero Infrastructure SEZ Ltd

S. Kullayi Reddy
Sr. General Manager -EHS

Enclosures : As above

SV ENVIRO LABS & CONSULTANTS

(Environmental Engineers & Consultants in Pollution Control)

Corporate Office & Laboratory : Enviro House, B-1, Block-B, IDA, Autonagar, Visakhapatnam-530012
www.svenvirolabs.com, Ph:0891-2755528, Cell: +91 9440338628
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Branch Office : 2-53, Mahipala Street, Yanam - 533464.

Recognized by **Govt.of India-MoEF & CC, New Delhi, Accredited by : NABL & NABET**

Date: 10th Januray 2022

To

Sr. General Manager -EHS,

M/s. Hetero Infrastructures SEZ Ltd

N. Narasapuram Village, Nallamattipalem Village,

Nakkapalli Mandal,

Visakhapatnam.

Sir,

Sub: Certified Compliance report for Environmental Clearance and CRZ Clearance of **M/s. Hetero Infrastructures SEZ Ltd** Audited by SV Enviro Labs & Consultants, NABL Accredited third party- Reg

Ref: 1) EC & CRZ Clearance F. No. 21-641/2007-IA.III, Date: 25.10.2010

We wish to inform you that, we SV Enviro Labs & Consultants, accredited by NABET/NABL located at Enviro House, B1, Block 'B'-IDA, Auto Nagar, Visakhapatnam herewith submit audited report for M/s. Hetero Infrastructures SEZ Ltd at Sy. No. 215, 286/1, 286/2, 283/1, in Ch. Lakshmi Puram, 312/1 to 312/5, 312/10 to 312/12, 313/1 to 313/7 of Rajaiahpet, 19(qart) in Pedda Teermala, 117/1 to 117/3, 119/1, 119/2, 120/1, 120/2, 125, 126, 129/1 to 129/9, 138, 142, 150, 215, N. Narasaraopuram Village, Nakkapally Mandal, Visakhapatnam for Environmental Clearance obtained from Ministry of Environment and Forests for the period of 01st July 2021 to 31st December 2021 after completing site visit.

With reference cited above, we have prepared certified compliance report for Environmental Clearance for the orders mentioned above vide reference numbers (1).

Thanks and Regards,

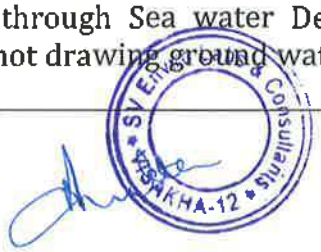
SV Enviro Labs & Consultants

Authorized Signatory

CERTIFIED COMPLIANCE REPORT OF ENVIRONMENTAL CLEARANCE
ISSUED BY SV ENVIRO LABS & CONSULTANTS
M/S. HETERO INFRASTRUCTURES SEZ LTD.,
NO: 21-641/2007-IA, III DATED 25TH OCTOBER 2010
EC COMPLIANCE PERIOD – JULY -2021 TO DECEMBER-2021

S.No.	Condition	Compliance
Part-A, Specific Conditions		
Construction Phase		
(i)	Consent for Establishment" shall be obtained from Andhra Pradesh Pollution Control Board under Air and Water Act and a shall be submitted to the Ministry before start of any construction work at the site.	**Complied.** The industry has obtained Consent for Establishment from AP Pollution Control Board. The Consent for Establishment vide Order No: 219/PCB/CFE/RO-VSP/HO/2010-2355, Issue date:13/12/2010
(ii)	Sufficient dilution shall be ensured to meet the ambient parameters within 50 m distance from outfall.	**Complied.** Out fall pipeline has been laid as per NIO recommendations for having sufficient dilution at the point of outfall. .
(iii)	Regular Independent monitoring of marine water quality including temperature and salinity at the outfall shall be undertaken through an authorized agency and submitted along with six monthly monitoring report to the ministry.	**Being followed.** The industry is taking expertise of NIO for conducting the studies and conducting the studies on yearly basis. Copy of the latest NIO report has already submitted to the Regional Office, MoEF & CC.
(iv)	Filters in the way of extruders shall be provided at the intake point to prevent fishes entering in the system.	**Complied by the industry.** Strainers have been provided at the intake point to prevent fish entry into the system.
(v)	The recommendations of EIA and DMP shall be strictly complied with.	**Complied.** The industry has followed all recommendation of EIA & DMP
(vi)	Lighted buoys shall be provided at intake and out fall location as indicators.	**Complied by the industry.** Marker Buoys have been installed at the intake & Outfall points as indicators.
(vii)	The pipeline shall be buried at least 2 m depth in onshore area and 4 mts in the offshore area. Necessary permission with regard to the pipeline burial and laying shall be obtained from maritime Board to ensure that the pipeline route does not fall in the navigation channel. Accordingly, the details of the laying of the pipeline shall be provided.	**Complied by the industry.** Pipeline has been laid as per the recommendations made by NIO. The pipeline route is not falling in the navigation channel

(viii)	The pipeline shall not pass through any sand dunes/mangroves. The project shall be implemented in such a manner that there is not damage whatsoever to the mangroves/other sensitive coastal ecosystem. If any damage to mangroves is anticipated/envisaged as a result of project activates then the clearance shall stand cancelled and the proponents shall seek fresh approval from the Ministry.	**Not applicable.** There are no mangroves and sand dunes in the area where pipeline has been laid.
(ix)	The reject shall meet the standards prescribed by Andhra Pradesh Pollution Control Board before disposal.	**Complied by the industry.** The rejects are meeting the standards laid down by APPCB as we are using Hypo & Ferric Chloride only as and when required depending on Sea water quality.
(x)	A continuous and comprehensive post project marine quality monitoring programmed shall be taken up. This shall include monitoring of water quality sediments quality and biological characteristics and report submitted every 6 months to Ministry's Regional Office at Bangalore.	**Being followed.** The industry is conducting post project marine monitoring through NIO once in a year i.e pre-monsoon & Post-monsoon Seasons. Copy of latest study report is enclosed as ***Annexure-I***
(xi)	It shall be ensured that there is no displacement of people, houses or fishing activity as a result of the project.	**Complied by the industry.** The Land of the project is used to be a vacant land used for aquaculture in the past and there is no displacement of people, houses or fishing activity as a result of the project.
(xii)	There shall be display boards at critical locations along the pipeline Viz. road / rail/ river crossing giving emergency instructions. This will ensure prompt information regarding locations of accident during any Emergency. Emergency information Board shall contain emergency instruction in addition to contact details. Proper lighting shall be provided all along the road.	**Complied by the industry.** The pipeline is completely laid in M/s Hetero Infrastructure SEZ Ltd area and only one crossing is there (Creek & Village Road) along the pipeline. Industry has taken all necessary precautions at the crossing. 24x7 security surveillance is in place all along the pipeline and Emergency contact details are available in the ECC & also at Security. Lighting has been provided all along the roads.
(xiii)	There shall be no withdrawal of ground water in CRZ area for this project.	**Complied by the industry.** The total water requirement of the facility is being met through Sea water Desalination plants and not drawing ground water for any purpose.



(xiv)	No other activities except the permissible actions under CRZ Notification 1991 shall be carried out with CRZ areas.	**Complied.** Industry is adhering with the conditions stipulated.
(xv)	Soil and ground water samples will be tested to ascertain that there is no threat to ground water quality by leaching of heavy metals and other toxic contamination.	**Complied.** The industry is conducting the analysis of soil & ground water periodically to check the contamination (if any). Copy of Latest Analysis report is enclosed as ***Annexure – II***.
(xvi)	Construction spoils, including bituminous material and other hazardous materials must not be allowed to contaminate water courses and the dump sites for such material must be secured so that they should not leach into the ground water.	**Complied.** The industry is not using any bitumen for construction of roads as all the roads are made of concrete only. Hazardous material is being disposed to authorized agencies (TSDF & Cement Industries) as directed by the APPCB in their Consent. There are no dump sites for waste material around the factory premises.
(xvii)	Any hazardous waste generated during construction phase should be disposed off as per applicable rules and norms with necessary approval of the Andhra Pradesh state Pollution Control Board.	**Complying.** The industry has followed Hazardous waste generated during construction phase was disposed as per applicable rules and norms with necessary approval of APPCB.
(xviii)	The diesel generator sets to be used during construction phase should be low Sulphur diesel type and should conform to Environment (Protection) Rules prescribed for air and noise emission standards.	**Complied.** The industry is using only low Sulphur diesel for operation of DG sets.
(xix)	The diesel required for operation DG sets shall be stored in underground tanks and required clearance from Chief Control of Explosives shall be taken.	**Complied.** The industry is storing diesel in dedicated above ground storage tanks and got clearance from Chief Controller of Explosives, Nagpur for various units located in Hetero Infra SEZ Ltd.
(xx)	Vehicles hired for bringing construction material to the site should be in good condition and should have a pollution check certificate and should conform to applicable air and noise emission standards and should be operated only during non-peak hours	**Complied by the industry.** All vehicles hired by the company are in good condition and having pollution check certificates. The vehicle movement in the premises is restricted to day time only.
(xxi)	Ambient noise levels should conform to residential standards both during day and night. Incremental pollution loads on the ambient air and noise quality should	**Complied.** At present there are no major construction activities at site

	be closely monitored during construction phase. Adequate measures should be made to reduce ambient air and noise level during construction phase, so as to conform to the stipulated standards by CPCB/SPCB	As per records noise levels found to be within limits.
(xxii)	Fly ash should be used as building material in the construction as per the provision of Fly ash Notification of september,1999 and amended as on 27th August,2003	**Complied.** The industry utilized fly ash Bricks & also using fly ash in Ready Mix concrete for the construction purpose for any maintenance.
(xxiii)	Ready mixed concrete must be used in building construction	**Complied.** Ready mix concrete was used for the construction of buildings during construction phase. At present there are no major construction activities at site.
(xxiv)	Storm water control and its re use as per CGWB and BIS standards for various applications.	**Complied.** Dedicated storm water drains have been constructed in the plant and rain water is being collected in the pond created by the industry for usage (as per the requirement).
xxv	Water demand during construction should be reduced by use of pre-mixed concrete, curing agents and other best practices referred	**Complied.** The industry used Ready mix concrete for the construction and used curing chemicals for curing purpose. At present there are no major construction activities at site.
xxvi	Permission to draw ground water shall be obtained from the competent Authority prior to construction/operation of the project.	**NOT APPLICABLE** The industry is not drawing any ground water and using water from Sea water desalination plant for its usage.
xxvii	Regular supervision of the above and other measure for monitoring should be in place all through the construction phase, so as to avoid disturbance to the surroundings.	**Complied.** The industry is Regular supervision by the Environment Department head to avoid disturbance to the surroundings
xxviii	Under the provisions of Environment (protection)Act,1986,legal action shall be initiated against the project proponent if it was found that construction of the project has started without obtaining environmental clearance	**Complied.** The industry has construction activities were started after getting Environmental Clearance only.
II. Operation Phase		
I	The installation of the Effluent Treatment Plant (ETP) should be certified by an	**Complied.**

SV Enviro Labs & Consultants VISAKHA-12

	independent expert and a report in this regard should be submitted to the Ministry before the project is commissioned for operation. Treated effluent emanating from ETP shall be Recycled/ Reused to the maximum extent possible.	The industry has constructed full-fledged ETP for the treatment of Effluents at a cost of Rs.80.00 Cores. The ETP design was certified by the third party and the copy of report has been submitted to RO, MoEF & CC along with compliance reports.
ii	The solid waste generated should be properly collected and segregated. Wet garbage should be composed and dry/inert solid waste should be disposed off to the approved sites for land filling after recovering recyclable material	**Complied.** Dedicated places have been provided for storing solid waste. Installed Organic Waste Converter & Vermi-compost plant for disposing wet garbage and canteen waste. Inorganic salts are being disposed to TSDF Visakhapatnam whereas the organic wastes are being disposed to cement plants for co-incineration (Alternate Fuel).
Iii	Diesel power generating sets proposed as sources of backup power for elevators and common area illumination during operation phase should be of enclosed type and conform to rules made under the environment (protection) Act,1986. The height of stack of DG sets should be equal to the height needed for the combined capacity of all proposed DG sets. Use low sulphur diesel. The location of the DG sets may be decided with in consultation with Andhra Pradesh State Pollution Control Board.	**Complied by the industry.** The Diesel generators are provided with acoustic enclosures and the stack height of the same is as per the norms prescribed by the Board. Using only low sulphur diesel for operation of the DG sets.
Iv	Noise should be controlled to ensure that it does not exceed the prescribed standards. During night time the noise levels measured at the boundary of the periphery of the plot shall be restricted to the permissible levels to comply with the prevalent regulations.	**Complied.** The industry is regularly monitoring the noise levels in & around the factory premises and found values are well within the norms. The Industry is taking all possible measures to control the noise pollution.
V	The green belt of adequate width and density preferably with local species along the periphery of the plot shall be raised so as to provide protection against particulates and noise.	**Complied.** The industry has planted around 500000 saplings in and around the premises.
vi	Weep holes in the compound walls shall be provided to ensure natural drainage of rain water in the catchment area during the monsoon period	**Complied by the industry.** Weep holes are provided in the compound walls to ensure natural drainage of rainwater in the catchment area during the

		monsoon period. In addition to that Well-designed drainage system is in place for the entire premises.
vii	Rain water harvesting for roof run-off, as plan submitted should be implemented. Before recharging the surface run off. pre-treatment must done to remove suspended matter,	**Complied.** The Complete rainwater is being collected in a pond created by the industry for naturally recharging the ground water and the same is being reused for utilities (if requirement arises).
viii	The ground water level and its quality should be monitored regularly in consultation with Central ground water authority	**Complied by the industry.** Ground water Levels and quality are being monitored on quarterly basis through third party (MoEF&CC approved Laboratory). Copy of report is attached as ***Annexure -III***
ix	Traffic congestion near the entry and exit points from the roads adjoining the proposed project site must be avoided. Parking should be fully internalized and no public space should be utilized	**Complied.** There is no traffic congestion near entry & exist points. The industry is using its own parking area and no public space is being utilized.
x	A report on the energy conservation measures confirming to energy conservation norms finalized by Bureau of Energy should be prepared incorporating details about building materials & technology & Factors etc and submit to the Ministry in three months time.	**Complied.** The study has been done on energy conservation measures and report is in place.
xi	Energy conservation measure like installation of CFLs/TFLs for the lighting the areas outside the building should be integral part of the project design and should in place before project commissioning. Use CFL and TFLs should be properly collected and disposed off/sent for recycling as per the prevailing guidelines/rules of the regulatory authority to avoided mercury contamination. Use of solar panels may be done to the extent possible.	**Complied.** Using CFLs/TFLs for the lighting area and these are the integral part of the project. At present the industry is in the process of replacing CFL/TFL s with LED lights for lighting purpose in and around the premises.
PART-B, GENERAL CONDITIONS		
i	The environmental safe guards contained in the EIA report should be implemented in letter and spirit.	**Complied.** The industry has implemented the environmental safe guards contained in the EIA report.

ii	The project proponent shall also submit six monthly reports on the status of compliance of the stipulated EC conditions including results of monitored data (hard copies as well as by e -mail) to the respective Regional Office of MoEF, the respective Zonal Office of CPCB and the SPCB.	**Complied.** The industry has regularly submitted the EC compliance reports to Regional Office to MoEF & CC as per condition wise. The same report has submitted to APPCB.
iii	Officials from the Regional Office of MoEF, Bangalore who would be monitoring the implementation of environment safeguards should be given full cooperation, facilities and documents /data by the project proponents during their inspection. A complete set of all the documents submitted to MoEF should be forwarded to the CCF, Regional Office of MoEF, Bangalore.	**Noted and will be followed.**
iv	In the case of any change(s) in the scope of the project, the project would require a fresh appraisal by this Ministry	**Agreed to comply.** There are no changes in the project. The Industry will approach the Ministry in case If any changes in the scope of the project.
v	The ministry reserves the right to added additional safeguard measures subsequently if found necessary, and to take action including revoking of the environment clearance under provisions of the environmental (protection)Act,1986, ensure effective implementation of the suggested safeguard measures in a time bound and satisfactory manner.	**Noted and agreed to comply.**
vi	All other statutory clearances such as the approvals for storage of diesel from Chief Controller of explosive, Fire Department, Civil Aviation department, forest Conservation Act 1980 and Wildlife (Protection) Act 1972 etc. shall be obtained, as applicable by project proponents from the respective competent authorities.	**Complied.** The industry is got approval for storage of Diesel in the individual units of SEZ and Fire NOC from Fire Services Department for Hetero Infrastructure SEZ Ltd & also individual units of Hetero SEZ.
vii	These stipulation would be enforced among others under the provisions of Water (prevention and Control of pollution) Act 1974,the Air(Prevention and control)act1981 the Environment (protection) Act 1986 ,the public Liability insurance)Act 1981 and EIA Notification,2006	**Noted and will be followed.**

viii	The project proponent should advertise in at least two local Newspapers widely circulated in the region one of which shall be in the vernacular language informing that the project has been accorded Environmental Clearance and copies of clearance letters are available with the Kerala Pollution Control Board and may also be seen on the website of the Ministry of Environment and Forest at http;// www.envfor.nic.in The advertisement should be within 10 days from the date of receipt of the Clearance letter and a copy of the same should be forwarded to the Regional office of this Ministry at Bangalore.	**Noted and complied.** The industry has submitted the Advertisement to Regional Office.
ix	Environmental clearance is subject to final order of the Hon'ble supreme court of India in the matter of Goa Foundation V/s Union of India in Writ petition (Civil) No.460 of 2004 as may be applicable to this project.	**Noted and agreed to comply.**
x	Any appeal against this Environmental Clearance shall lie with the National Environment Appellate Authority, if preferred, with a period of 30 days as prescribed under section 11 of the National Environment Appellate Act,19987	**Noted and accepted**
xi	A copy of the clearance letter shall be sent by the proponent to concerned panchayat, Zilla parishad/Municipal Corporation, Urban Local Body and the Local NGO, if any from whom suggestions/representation ,if any were received while processing the proposal. The clearance letter shall also be put on the website of the company by the proponent	**Complied.** The industry has submitted Copy of Environmental Clearance letter to the concerned Village Panchayat.
xii	The proponent shall upload the status of compliance of the stipulated EC conditions, including results of monitored data on their website and shall update the same periodically .It shall simultaneously be sent to the Regional Office of MoEF, the respective Zonal Office of CPCB and the SPCB. The criteria pollutant levels namely; SPM, RSPM, SO2, NOx (ambient levels as well as stack emissions) or critical sect oral parameters, indicated for the project shall be monitored and displayed at a convenient location near the main gate of the company in the public domain.	**Complied.** EC Letter & Its compliance status is available in the Company website www.heteroworld.com. Compliance of EC conditions are being sent to Regional Office, MoEF & CC regularly. Monitoring data is being submitted regularly to SPCB on monthly basis. The industry has Installed 03 No CAAQM stations in the premises and the data is being displayed at Main Gate through

		Digital/LED display.
xiii	The environmental statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment(protection)Rules,1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of EC conditions and shall also be sent to the respective Regional Offices of MoEF by e-mail	**Complied.** The industry is regularly submitting Environmental statement to APPCB before 30th September of every year and is uploaded in Company website www.heteroworld.com. . Copy of latest Environmental statement is enclosed as **Annexure-IV.**

DISTRIBUTION RESTRICTED

Monitoring of chemical and biological parameters in the marine environment off Rajayyapeta

SPONSORED BY

HETERO

Hetero Drugs Limited

CSIR - NATIONAL INSTITUTE OF OCEANOGRAPHY
(Council of Scientific & Industrial Research)
Regional Centre, Visakhapatnam – 530 017

April 2019

Contents

PR E F A C E

M/s. Hetero Drugs Limited, Nakkapalli, Visakhapatnam district, approached the CSIR-National Institute of Oceanography, Regional Centre at Visakhapatnam to carry out the third Post Project Monitoring of marine environment at its discharge point to know the impacts, if any on the ecology, water and sediment quality. In this connection, CSIR-NIO has conducted a field campaign on 17th April 2017 in marine outfall region of M/s Hetero Drugs Limited for in-situ observations and sample collection for the comprehensive study on water quality, biological, microbiological and sediment characteristics of the region. The following studies were carried out:

- Monitoring of chemical and biological parameters in the marine environment to assess the present status of marine ecology.
- Toxicological studies to know the survival rate of the test species with the treated effluent from their firm.

This report describes the results of the above studies and provides the recommendations to the Sponsor.

Station: Visakhapatnam (NPC REDDY)

Date: 10.04.2019 (Project Leader)

EXECUTIVE SUMMARY

M/s. Hetero Drugs Limited, Nakkapalli, Visakhapatnam district, Andhra Pradesh, requested CSIR - National Institute of Oceanography (NIO), Regional Centre, Visakhapatnam to carry out the third post project monitoring in the effluent disposal site to know the impacts, if any, on the ecology, water and sediment quality. Accordingly CSIR - NIO has studied the following aspects as part of post project monitoring:

a. Analyzing the chemical and biological parameters and sediment characteristics to know the current status of the marine environment.

b. Toxicological studies to assess the survival rate of the test species for the treated effluent.

Based on the above studies, the following suggestions and recommendations are made:

Chemical Studies:

The concentrations of all chemical constituents in the vicinity of the marine outfall are well within the ambient levels of coastal environment due to quicker dispersion and dilution at marine outfall after discharge. The range of values of pH (7.4-8.0), DO (2.7 to 6.0 mg/l), BOD (0.06-0.55 mg/l), NO_2-N (1.6-8.5 µg/l), NO_3-N (21.3-62.5 µg/l), PO_4-P (14.3-47.2 µg/l), SiO_4-Si (139-435 µg/l) and PHC (1.3-10.5 µg/l) of the present study are similar to those found in the earlier monitorings conducted during 2012 and 2014 in the same region, and also comparable with the adjacent coastal waters of east coast of India.

Biological Studies:

Biological characteristics of the study region are found to be normal and consistent with characteristics of adjacent coastal waters of east coast of India. No significant deviation was found in biological parameters from baseline data which was conducted prior to commencement of effluent discharge from the company and from

the earlier post project monitoring conducted during 2012 and 2014. Not much variation was found in the faunal diversity in and around the marine outfall point, indicating the even distribution of biological diversity. However, relatively higher zooplankton abundance during the present study was attributed to inter annual variability which is common in the coastal waters.

The range of population density of macrofauna found in this study (900 to 4650 individuals/m^2) is similar to the range of values obtained in earlier monitoring studies (125 to 3325 individuals/m^2). The total wet weight of biomass was in the range of 1.22 – 8.99 g/m^2. Polychaetes are the major contributor to the wet weight biomass, as was observed during previous monitoring studies conducted in the same region. The range of total count of meiofauna in the present study (416 - 1006 No/10cm^2; mean: 661 $\pm$186/10cm^2) is not far from range of values found in earlier monitoring studies (634 - 861/10cm^2; mean: 729$\pm$87/10cm^2) Nematodes were the most dominant group with a percent contribution of >80%, as was observed during previous studies in this region. Their numerical density is also did not change significantly from 2014 (365-622/10cm^2) to 2017 (311-710/10cm^2).

The range of total viable bacterial counts (TVC), total *coliform* and *E. Coli* like organisms (ECLO) in the surface waters (5.6 -13.6x10^3, 0.3-0.8x10^3 and 1.5-3.7x10^3 CFU/ml respectively) and bottom waters (3.2-33.0x10^3, 0.2-1.2x10^3 and 0.7-7.4x10^3 CFU/ml respectively) as well are within the range values reported for healthy coastal waters.

Toxicological studies conducted on test organisms of Tiger Shrimp Post Larvae (*Penaeus mondon*) and Fingerlings of grey mullet (*Mugil cephalus*) with different effluent concentrations for different time periods. Results showed that the mortality rate was >60% at 100% exposure for 96 hours, indicating that the effluent is mildly acute toxic. Hence, further treatment of effluent in the effluent treatment plant is recommended before discharging into the sea.

Periodical monitoring of the marine environment along with bio assay test is required to carry out with a frequency of once in two years is recommended.

CONTRIBUTORS TO THE PROJECT

Dr. G. P. S. Murthy	**Scientist-in-Charge**
Shri. N.P.C. Reddy	**Project Leader**

NIO, Regional Centre, Visakhapatnam

Dr. M. Sri Rama Krishna	Associate Project Leader
Dr. T. N. R. Srinivas	Member
Dr. L. Jagadeesan	Member
Dr. R. A. Sreepada	Member
Mr. D. Narasima Rao	Member
Mr. N. Surendra Babu	Member
Mr. S. Kuswanth Kumar	Member
Ms. D. Sree Lakshmi	Member

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Chapter 1
INTRODUCTION

1.1 Background information

M/s. Hetero Drugs Limited is a bulk drug complex situated at Nallamattipalem village in Nakkapalli Mandal of Visakhapatnam District, Andhra Pradesh (Figure 1.1). This plant is producing bulk drugs and their intermediates for the past few years. The industry is discharging the treated effluents into the sea through a pipeline at a distance of 980 m from the coast, a safe disposal for quick dispersion, as recommended by National Institute of Oceanography in their Rapid Marine Environmental Impact Assessment report of 2006. After commissioning the industry and discharging the treated effluents into the marine environment, Andhra Pradesh State Pollution Control Board (APPCB) insisted the firm to have regular post-project monitoring studies in the marine environment and bioassay tests for the treated effluents as a mandatory for a coastal based industry. Accordingly, N.I.O., Regional Centre, Visakhapatnam has carried out post project monitoring in 2010 and 2012 to know the impacts if any due to discharge of treated effluents. As part of the post project monitoring, once again the firm approached National Institute of Oceanography, Regional Centre, Visakhapatnam for these studies to know the cumulative effects, if any, on the ecology, water quality and sediment quality due to the discharge of treated effluents into the marine environment. After examining the proposal, NIO agreed to carry out the field study to generate one time site specific data on oceanographic parameters and bioassay studies on the treated effluents as part of the post project monitoring.

Fig. 1.1.: Hetero Complex

1.2 Details of Study

Generation of site specific environmental data base is a prerequisite for the assessment of probable impact of any coastal based industry. Hence it was planned to generate reliable data at least one time in respect of physical, chemical and biological parameters to understand the water quality and sediment quality in and around the marine out fall point (discharge point) covering 11 stations. Further the toxicological studies are important to assess the survival rate of species (prawn) and hence bioassay tests were conducted initially with the treated effluents on test organisms. The results of the monitoring in the marine environment conducted on 17

April 2017 and the toxicological studies on the treated effluents are given in this report.

1.3 Company Profile

M/s Hetero Drugs Ltd. and M/s Hetero Labs Ltd. is a Bulk Drug Manufacturing Complex with four units situated at N. Narasapuram, Nakkapalli – Mandal, Visakhapatnam –Dist of Andhra Pradesh. Out of four units two units are in non Special Economic Zone (SEZ) and two are in SEZ in the name of Hetero Infrastructure SEZ Ltd. The SEZ is also having the required infrastructure and pollution control facilities to operate the industrial estate.

The industrial estate is situated in Sy. Nos: 215, 286/1, 286/2, 283/1 in Ch. Lamxipuram village, 312/1 to 312/5, 312/10 to 312/12, 313/1 to 313/7 of Rajayyapeta village, 19(part) in Peda Teenarla village, 117/1 to 117/3, 119/1, 119/2, 120/1, 120/2, 125, 126, 129/1 to 129/9, 138, 142, 150, 215, N. Narsapuram village, Nakkapalli Mandal, Visakhapatnam District spread over an area of 139.856 ha. The various units which are working at present are as below:

- Hetero Drugs Limited, Unit-VI (Non SEZ)
- Hetero Labs Limited, Unit-III (Non SEZ)
- Hetero Drugs Limited, Unit-IX (SEZ)
- Hetero Labs Limited, Unit-IX (SEZ)

The Hetero complex (Figure 1.2) is surrounded by open lands & salt lake in the south direction, open lands in the east direction, open lands in north direction and road connecting Upamaka village with Rajayappeta village in the West direction, The NH 16 is in the north direction at a distance of 4 km, the nearest railway station is located at Narsipatnam at a distance of 9 km in the north direction. The nearest airport is located at a distance of 70 km in the north east direction at Visakhapatnam. The Bay of Bengal is on the south eastern direction of the site at a distance of 1.2km. The area is drained by Varaha River in the northern direction up to a distance of 13km, the Tandava River in the south west direction at a distance of 14km.

Fig. 1.2: Synoptic view of the Hetero Complex

The capital cost of the project is Rs 460 Crores. The SEZ is designed on the basis of required infrastructure for pharmaceutical manufacturing facilities like, road, storm water network, common utilities, storage facilities for raw materials, solvents, parking areas, pollution control facilities etc.

The water requirement of the project is being met with the sea water desalination plants (Fig. 1.3) installed in the premises of Hetero Infrastructure SEZ Ltd. Sewage treatment plant (Figs. 1.4 and 1.5) is provided to treat the waste water and effluent treatment plant, containing different stages of treatment (Figures 1.6 to 1.12) for industrial waste water. Water conservation measures were incorporated in the plumbing designs. Water recycling / reuse was adopted by way of using treated sewage for green belt development. The storm water from the site is collected in a storage tank and the same is reused for process, while the over flow is let out into the natural drain adjacent to the site. The required power is drawn from the AP TRANSCO and adopted energy efficient design for lighting and utilities systems

optimize the energy requirement. Construction material was drawn from local sources.

Amenities and utilities:

A number of amenities and utilities were implemented during the operation phase to provide common infrastructure and pollution control facilities.

Fig. 1.3: Desalination plant in the Hetero Premises

Fig. 1.4: Sewage Treatment Plant (STP)

Fig. 1.5: Vermi Compost Plant

Fig. 1.6: Stripper and MEE (I & II)

Fig. 1.7: ATFD Connected to MEE I & II

Fig. 1.8: HTDS Tanks covered with Hoods and connected to Scrubbers

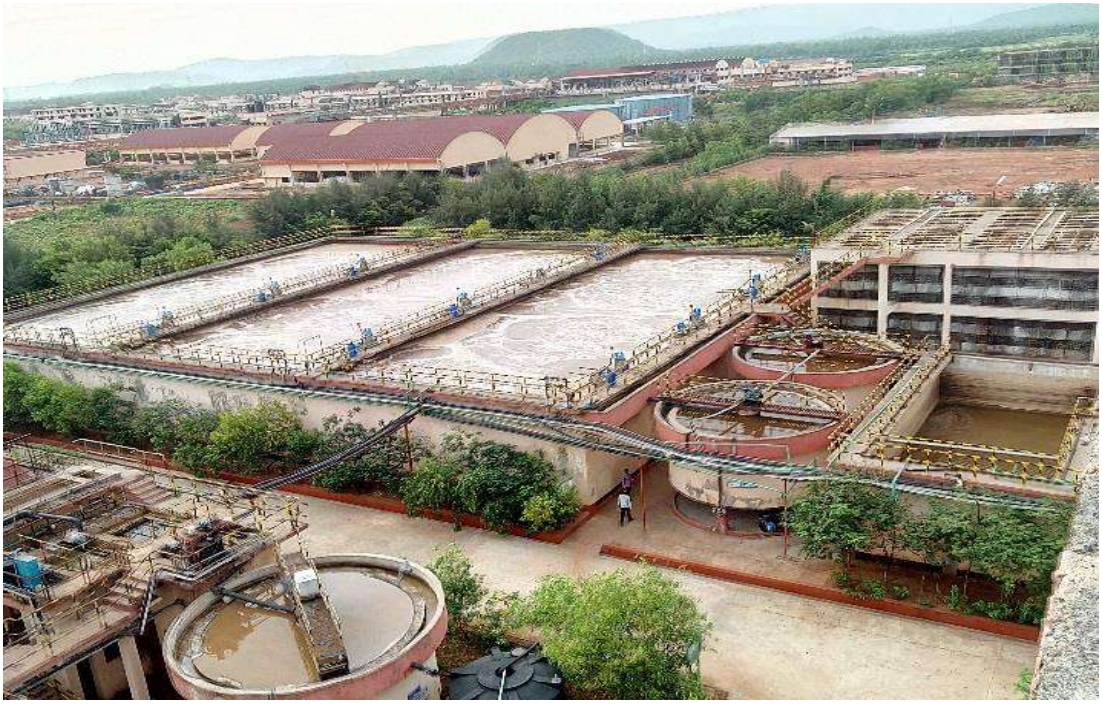


Fig. 1.9: Biological system for LTDS & Condensate of MEE & ATFD

Fig. 1.10: Guard ponds for storage of treated Effluent

Fig. 1.11: Aeration tanks

Fig. 1.12: Aeration in the effluent treatment process

Baseline environment:

The baseline environment of the project impact areas (PIA) spread over 25km radius from the site was studied for air, water , soil, noise , ecological and social economic status. The baseline status is found to be within the prescribed limits in all respects except the noise levels which are found to be above the prescribed limits during day time in the PIA.

1.4 Major Products:

Table 1.1: List of Products of Hetero Drugs Limited, UNIT-VI

Group –A (Regular Products)

S. No	Products	Quantity (Kg/Day)
1	Atorvastatin Calcium	131.50
2	Cefditorine Pivoxil	131.50
3	Cefidenir	65.8
4	Cefixime	493.2
5	Ceforoxime Axetil	65.80
6	Cefoxitin Sodium	98.6
7	Cefpoxidime Proxetil	328.8
8	Citaloporam Hydro Bromide	246.6
9	Laminudine	49.3
10	Ritanovir	82.2
11	Rosiglitazone Maleate	32.9
12	Venilafaxine	41.1
Production Capacity for worst case		**1644**

Group –B (Campaign Products)

1	Acyclovir	32.9
2	Agomelatine	16.4
3	Alfuzocin HCl	32.9
4	Amlodipine Besylate	24.7
5	Clopidogrel Hydrogen Sulfate	32.9
6	Dapoxetine HCL	24.7
7	Dorzolamide HCL	4.9
8	Duloxitine HCL	24.7
9	Eprosartan Mesylate	16.4
10	Esamoprazole Magensium	32.9
11	Famcyclovir	32.9
12	Fosinopril Sodium	32.9
13	Glimpiride	32.9
14	Itraconazole	24.7
15	Lansoprozole	32.9
16	Levofloxacin	24.7
17	Lisinopril Dehydrate	32.9
18	Montelukast Sodium	32.9
19	Moxifloxacin	32.9
20	Nebivolol HCL	24.7
21	Olanzapine	32.9
22	Omeprazole	32.9
23	Pentaprazole Sodium	24.7
24	Rabeprazole Sodium	24.7
25	Ranolazin Di HCL	16.4
26	Rufinamide	16.4
27	Sertraline HCL	32.9
28	Sedinafil Citrate	32.9
29	Topiramate	32.9
30	Valacyclovir	65.8
Production Capacity for Worst case		**329**

Total Production Capacity in Worst Case : 1973 Kgs/day

Note: Industry should manufacture only 09 products from Group –A and 9 products from Group –B at any given point of time.

Table 1.2: List of Products of Hetero Labs LTD (UNIT – III)

Group – A (Regular Products)

S. No	Name of the Product	Quantity (Kg/Day)
1	Abacavir Sulphate	32.9
2	Efavirenz	131.5
3	Escitalopram Oxalate	328.8
4	Fosamprevavir	115.1
5	Hydralazine HCL	32.9
6	Indinavir	164.4
7	Irbesartan	32.9
8	Lamivudine	328.8
9	Leviteracetam	32.9
10	Losartan Potassium	32.9
11	Maraviroc	32.9
12	Nevirapine	98.6
13	Pioglitazone HCL	32.9
14	Quetiapine Fumerate	32.9
15	Raltagravir	32.9
16	Stavudine	32.9
17	Telmisartan	32.9
18	Tenofovir Disproxil Fumerate	328.8
19	Terbinafine HCl	32.9
20	Zidovudine	82.2
Total Production capacity for worst cases		1644.00

Group – B (Campaign Products)

S. No	Name of the Product	Quantity (Kg/Day)
1	Alendronate Sodium	3.3
2	Aliskiren Hemifumarate	6.6
3	Aripiprazole	3.3
4	Atazanavir Sulpahte	32.9
5	Atomoxetine HCl	3.3
6	Benezapril HCl	3.3
7	Butenafine Hcl	0.7
8	Candesartan Cilexetil	16.4
9	Cilazapril Monohydrate	3.3
10	Cilostazol	24.7
11	Darunavir	24.7
12	Deflazcort	1.6
13	Desloratadine	1.6
14	Didanosine	32.9
15	Emtricitabine	32.9

16	Eplerenone	1.6
17	Ezetimibe	32.9
18	Feropenem Sodium	3.3
19	Fluticasone	0.3
20	Lopinavir	32.9
21	Loratidine	6.6
22	Maliniciparm HCl	1.6
23	Mifepristone	3.3
24	Miglitol	1.6
25	Moxatidine	32.9
26	Nadifloxacin	0.7
27	Nelfinavir	32.9
28	Osaltamivir Phosphate	24.7
29	Ozagrel HCl	3.3
30	Pamidronate Sodium	3.3
31	Posaconazole	32.9
32	Ramipril	32.9
33	Rasagline Mesylate	3.3
34	Residronate Sodium	3.3
35	Rufinamide	3.3
36	Rupatadine Fumarate	3.3
37	Sequinavir Mesylate	26.3
38	Simvastatin	26.3
39	Sumatriptan Succinate	3.3
40	Tazarotaine	1.6
41	Tegaserod Maleate	1.6
42	Tiagabine	32.9
43	Tioconazole	26.3
44	Torsemide	8.2
45	Valsartan	32.9
46	Voricanazole	32.9
47	Zonisamide	6.6
Total production capacity for worst case		**329.00**

Total production capacity for worst case from Group A & B is 1973 Kg
Note: Industry should manufacture only 10 products from Group –A and 10 products from Group –B at any given point of time.

Table 1.3: List of Products of Hetero Labs LTD (UNIT – IX)

S. No	Name of the Product	Quantity (Kg/Day)
1	Abacavir Sulphate	164.4
2	Efavirenz	1643.8
3	Fosamprevavir	16.4
4	Lamivudine	1643.8
5	Leviteracetam	657.5
6	Nevirapine	1643.8
7	Stavudine	164.4
8	Tenofovir Disproxil Fumerate	986.3
9	Zidovudine	1643.8

Total Production Capacity per month is 260 MT

Table 1.4: List of Products of Hetero Drugs Limited, Unit-IX

Group – A (Regular Products)

S. No	Products	Quantity Kg/day)
1	Acyclvir	657.5
2	Azithromycin	493.5
3	Celecoxib	657.5
4	Citaloparm hydro bromide	230.1
5	Fexofenadine	493.2
6	Gabapentine	789
7	Nabimitone	657.5
8	Naproxen	821.9
9	Nageglinide	657.5
10	Ritanovir	493.2
11	Sertraline HCl	493.2
12	Sevelamir HCL	493.2
Total 9 Products at any point of time		

Group – B (Campaign Products)

1	Adefovir dipivoxil	6.6
2	Alvimopan Dihydrate	24.7
3	Darifenacin Hydrobromide	9.9
4	Eletripan Hydrobromide	32.9
5	Ezetimbe	65.8
6	Fluvastatin Sodium	49.3
7	Gancyclovir	3.3
8	Isradipine	24.7
9	Lopinavir	65.8
10	Mamantine HCL	24.7
11	Nisoldipine	16.4
12	Orlistat	16.4
13	Rizatriptan	16.4
14	Relaxifene Hydro chloride	65.8
15	Rivastigimine Tartrate	16.4
16	Rizatriptan	16.4
17	Ropinirole Hydrochloride	16.4
18	Roruvastin	49.3
19	Rufinamide	16.4
20	Tadalafil	16.4
21	Trospium Chloride	32.9
22	Valgaciclovir	16.4
23	Vardenafil Hydrochloride	16.4
24	Zolmitriptan	16.4
Total 9 Products at any point of time		

Table 1.5: Effluent Generation per day

S.NO	UNIT	HTDS & HCOD KLD	LTDS & HCOD KLD	LTDS & LCOD KLD	RO Rejects KLD	Domestic KLD	Total Effluent Generation KLPD
1	HDL -IX	79.197	9.357	4	0	25	117.554
2	HDL-VI	80.59	0	15	86.78	25	207.37
3	HLL- IX	101.142	75.176	4	0	25	205.318
4	HLL- III	76.7		19.5	86.78	25	207.98
TOTAL		**337.629**	**84.533**	**42.5**	**173.56**	**100**	**738.222**

Table 1.6: Water Consumption as per Consents

S.NO	UNIT	PURPOSE (KLPD)					Total Water Consumption KLPD
		Process and Washings	Boiler	Cooling	Domestic	Additional Water to RO	
1	HDL -IX	88.5	40	40	25	0	193.5
2	HDL-VI	80.59	27	24	25	84.01	240.6
3	HLL---IX	176	50	50	25	0	301
4	HLL---III	85.21	27	24	25	86.78	247.99
TOTAL							**983.09**

Table 1.7: Details of Boilers

S. No	Details of units	Capacity
1	NR Units (HDL-VI)	20 TPH
2	For Hetero Infra SEZ Lts	1 x 10 TPH
		2 X 6 TPH

1.5 Green Belt Development

Green belt is recommended as one of the major components of Environmental Management Plan. The existing industry has green belt and the management emphasizes the development of further greening of the site to enhance environmental quality through mitigation of fugitive emissions, attenuation of noise levels, balancing eco-environment, consumption of treated effluent, prevention of soil erosion, and creation of aesthetic environment. The greenbelt is in an area of 124.5 acres. The enhancement of green belt involved plantation of small species. Proper attention and management is being taken up by the firm to maintain the survival rate of the planted species. For plantation of small plants digging of pits is very important for preparing soil environment near the roots of the plants. Size of the pit will be optimum enough to supply required nutrients to the roots of the plant. The usual method is to dig pit of required size three to four months before planting of the species, which is generally done at the break of the monsoon. The pits of 45 cm x 45 cm x 45 cm size in case of hardier spices like Eucalyptus, Shisham, Acacia etc., but larger pit size is preferred for fruit yielding trees like mango, Jamun etc. 1m x 1m x 1m pits may be used for plantation of other trees. The soils of the plant side will be mixed with 1/3 farmyard manure before refilling about a week prior to planting.

M/s. Hetero Labs Ltd. units are having good environment management plan and made this as part of their corporate policies. The firm has considered Safety, Health and Environmental protection as the integral part of their business. As a part of environmental management plan the firm established and developed green belt in and around each block of the plant (Figures 1.13 to1.18).

Fig. 1.13: Green Belt inside the factory

Fig. 1.14: Green Belt outside the factory

Fig. 1.15: Green Belt in ETP area

Fig. 1.16: RCC Road connected to Boilers with Green Belt

Fig. 1.17: Green Belt in the Hetero premises

Fig. 1.18: Green Belt inside the company

Chapter 2
CHEMICAL STUDIES

2.1. Plan of Work

Sampling was carried out at 11 stations, including the marine outfall point (MOP). The stations are located at a distance of 0.5, 1.0 and 2.0 km towards north, south and east of the out fall point (OFP) (Fig. 2.1) within the depth range of 9-16 m wherein water and sediment samples were collected for chemical analysis on 17th April 2017. The main objective of the work is to know the current status of the marine environment and impacts, if any, after discharging the treated effluents from the firm.

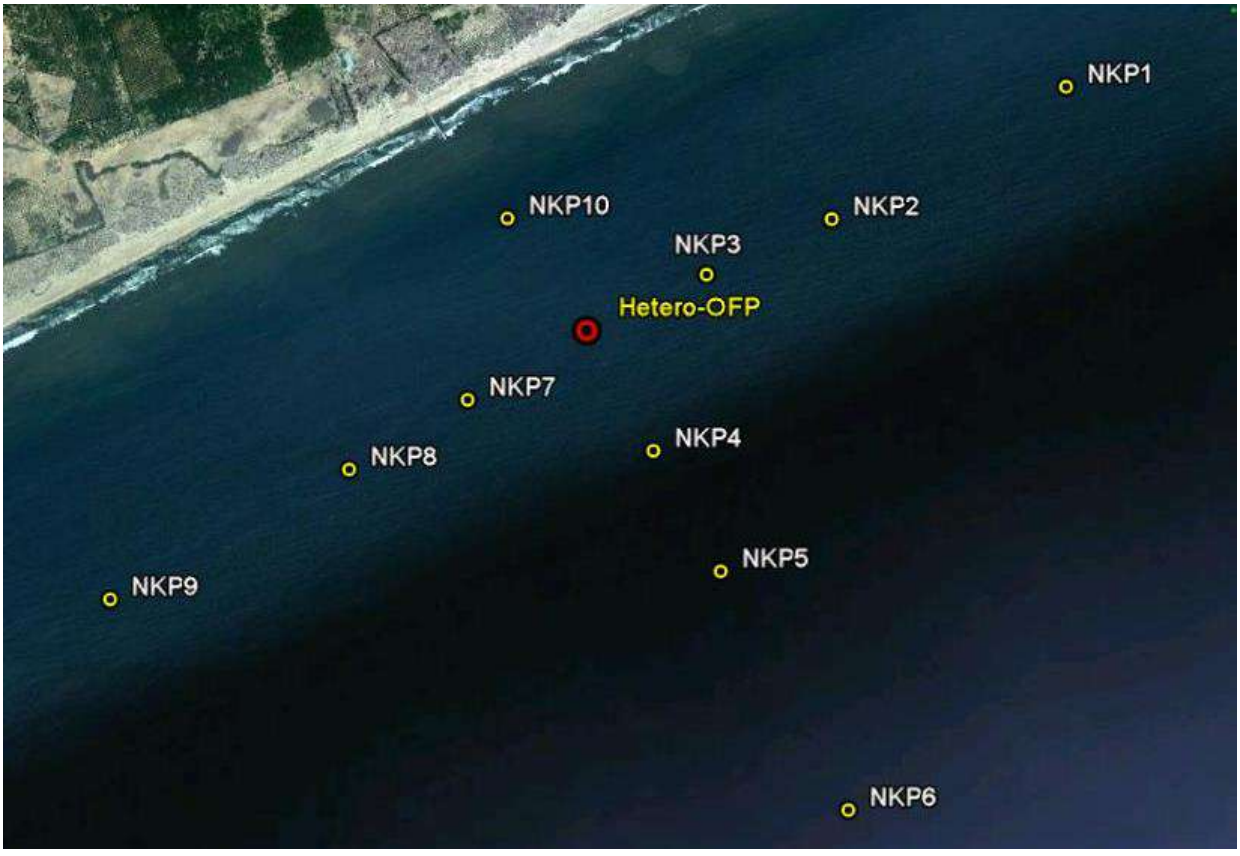


Fig. 2.1: Station Location Map

2.2 Chemical Characteristics

2.2.1 Sampling and Analysis

A Niskin Water sampler has been used for collection of water samples from surface and near bottom depths (Figs. 2.2 a and b). Water samples were collected in pre cleaned glass/plastic bottles as soon as the water sampler brought to the deck (Figs. 2.3). The samples were fixed immediately for dissolved oxygen (DO) after collection. Samples for nutrient analysis were collected in plastic bottles and kept frozen until the samples reached shore laboratory. Analysis was carried out within the stipulated period of time in the shore laboratory.

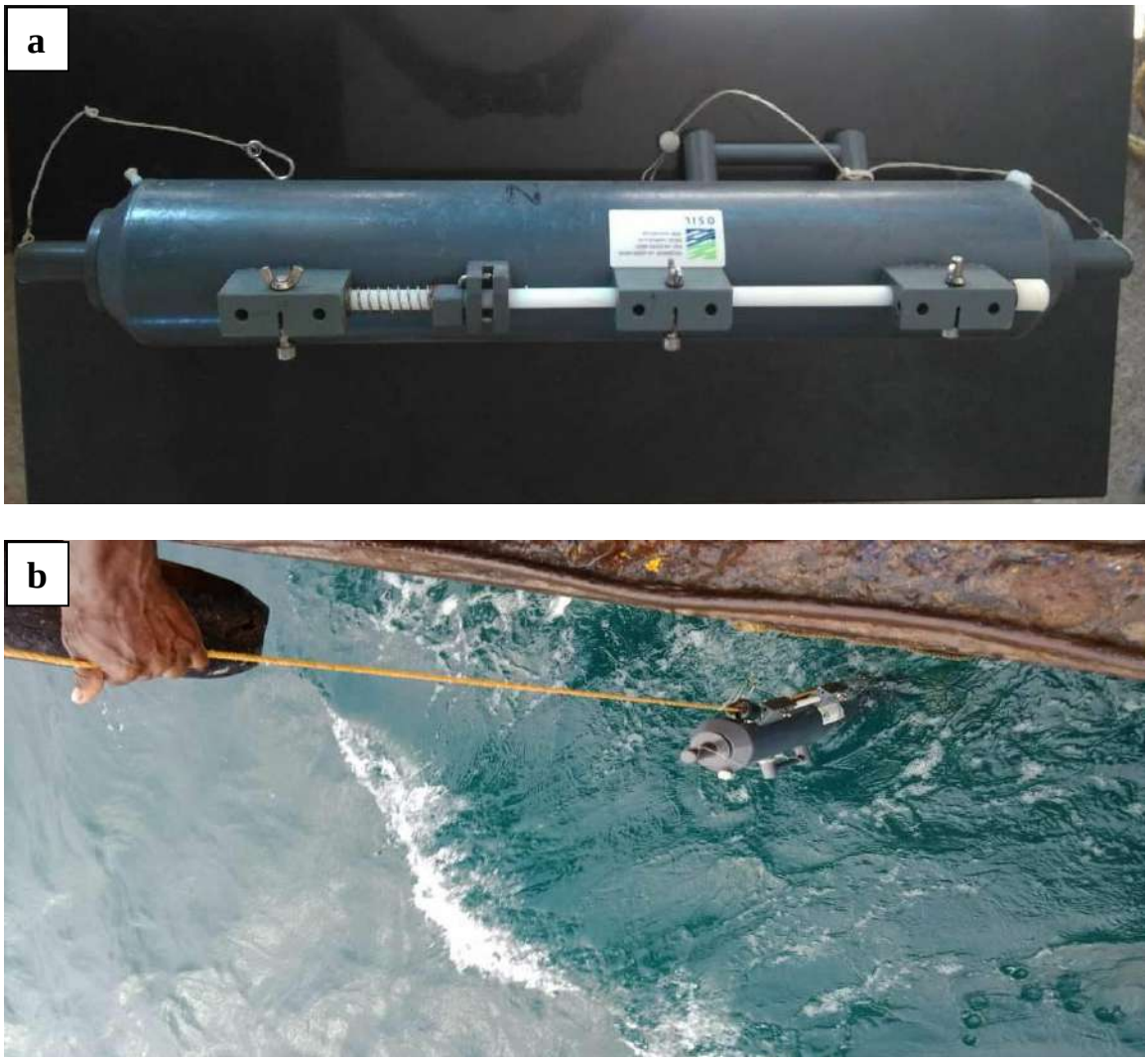


Fig. 2.2: (a) Niskin water sampler (b) operation of Niskin sampler

Fig. 2.3: Collection of water samples from Niskin sampler

2.2.1.1. pH

pH of the sea water sample collected in air-tight glass bottle (60ml) was measured using Metrohm pH analyzer (Titrando 865). Standard buffer solutions (Merck, Germany) were used for calibration of the instrument. Based on the repeated analysis of aliquots of standards and samples, the precision of the analysis for pH is 0.002 units.

2.2.1.2 Dissolved Oxygen (DO)

Winkler's method was adopted for the determination of DO by fixing a measured volume of water sample immediately after collection with the reagents A (manganous chloride) and B (alkaline potassium iodide). Standard titration with sodium

thiosulphate is adopted for the analysis purpose. Concentration of DO is expressed in mg/l. The precision of analysis, expressed as standard deviation, is ±0.07%

2.2.1.3 Biochemical Oxygen Demand (BOD)

Samples for the determination of biochemical oxygen demand were collected in triplicate. The dissolved oxygen concentration was immediately determined using one of the triplicate samples according to Winkler Method. The remaining bottles were left for five days at 20ºC in the BOD incubator. Dissolved oxygen in these samples was determined after fixing the samples on completion of five days incubation. BOD was computed from the initial DO concentrations and expressed in mg/l/day.

2.2.1.4 Ammonia - Nitrogen (NH_4 - N)

Ammonia - Nitrogen in seawater samples was determined with the indophenol blue method using trione. Care should be taken for the analysis of ammonia and the distilled water should be ammonia free and afresh to avoid any contamination as ammonia is highly soluble in water. The absorbance measurements were made at 630 nm in Spectrophotometer against a standard. NH_4 - N is expressed in µmol/l and the precision of analysis, in terms of standard deviation, is ±0.02 µmol/l

2.2.1.5. Nitrite - Nitrogen (NO_2 - N)

Nitrite was determined by the method of Bend Schneider and Robinson whereby the nitrite in water sample was diazotised with sulphanilamide and coupling with N-1-Naphthyl ethylene diamine dihydrochloride. The absorbance of the resultant azo-dye was measured at 543 nm against a standard solution. NO_2^-- N is expressed in µmol/l.

2.2.1.6 Nitrate - Nitrogen (NO_3 - N)

Nitrate in seawater sample was first reduced to nitrite by heterogeneous reduction by passing the buffered samples through an amalgamated cadmium column and the resultant nitrite was determined as above. The measured absorbance was due to initial nitrite in the sample and nitrite obtained after reduction of nitrate. Necessary correction was therefore applied for any nitrite initially present in the sample. NO_3^-- N is expressed in µmol/l. The precision of analysis for both nitrite and nitrate, in terms of standard deviation, is ±0.02 µmol/l

2.2.1.7 Phosphate - Phosphorus (PO_4 -P)

Dissolved inorganic phosphate was measured by the method of Murphy and Riley in which the samples were made to react with acidified molybdate reagent and then reduced using ascorbic acid. The absorbance of the resultant phosphorous molybdenum blue complex was measured at 880 nm against a standard. PO_4^{3-}- P is expressed in µmol/l. The precision of analysis, in terms of standard deviation, is ±0.01 µmol/l

2.2.1.8. Silicate - Silicon (SiO_4 - Si)

Silicate - silicon was also estimated by reaction with acid - molybdate and ascorbic acid in the presence of oxalic acid. The interference of phosphate is prevented by addition of oxalic acid. The absorbance of the resultant silico - molybdenum blue complex was measured at 810 nm in Spectrophotometer against a standard. SiO_4^{2-}- Si is expressed in µmol/l. The precision of analysis, expressed as standard deviation, is ±0.02 µmol/l

2.2.1.9 Total Suspended Matter (TSM)

One litre of sample was filtered through preweighed Polycarbonate filter (0.47 µm) millipore and after filtration the filter was weighed again after drying constantly at 60°C and the difference in weight was considered as TSM and is expressed mg/l.

2.2.1.10 Petroleum Hydrocarbons (PHC)

Dissolved or dispersed petroleum hydrocarbons were extracted from sea water thrice with n-hexane. Biogenic hydrocarbons are removed by passing the extract through silica gel. Hydrocarbons from anthropogenic sources are detected from the samples using fluorescence spectrophotometer. Reference materials used for quantifying petroleum hydrocarbons was taken from MA field crude oil of RIL. Concentrations of PHC dissolved in sea water are expressed in µg/l.

2.3 RESULTS

2.3.1 Water Quality

Baseline data on environmental parameters are prerequisite for understanding the impact of any developmental activity to assess the environmental quality before, during and after such an activity. In order to assess the quality of the waters, it is essential to study the spatial and temporal variations of these parameters in the potential impact zone in the coastal waters of the proposed discharge point. The concentrations of hydrochemical characteristics in the marine environment off Nakkapalli are shown in Tables 2.1 & 2.2.

Salinity is the most important hydrographical parameter, which tremendously influences almost all other physical and chemical properties of the water column and considerably determines the distribution of biological communities. The surface salinity is in the range of 32.92 to 34.38 PSU while the bottom between 34.37 to 34.63 PSU. These values are within the range of ambient sea water conditions.

Temperature is the second important hydrographical parameter which influences almost every biochemical interaction taking place in body tissues of organisms and also chemical interactions and admixing of different water masses. But, it always acts as a co-variate rather than as an independent factor. Owing to its important role on the hydro-chemical cycles and bio-geo-chemical transfer process of elements in an ecosystem, equal importance is given to the study of temperature along with the salinity in the marine and estuarine ecosystems. Surface temperatures ranged between 28.3 and 30.0°C while in the bottom waters it varied between 25.7 and 26.9 °C. Sea surface salinity in the study region varied very narrowly from 32.92 to 34.38, consistent with adjacent coastal waters.

pH values during the study period ranged from 7.4 to 8.0 in the surface whereas it varied from 7.5 to 8.0 in bottom waters of the study area. The variations of pH between surface and bottom waters are marginal and these values can be compared with that of clean tropical coastal waters.

Dissolved oxygen (DO) participates in many chemical and biological processes taking place in ambience, and therefore, its distribution form an important hydrographical parameters in both oceanographic and marine biological studies. Dissolved Oxygen (DO) in the surface waters varied from 2.7 to 6.0 mg/l while in the bottom waters it varied between 3.3 and 5.9 mg/l in the study region. The range of DO values found in this region during the study period are comparable to those found in the coastal regions along east coast of India. Low concentrations of DO values in the bottom waters are common and it is mainly due to decomposition of organic matter which consumes oxygen and releases carbon dioxide. It could also be due to

vertical stratification as evidenced by vertical distribution of temperature and salinity during the study period.

The range of BOD values found in both surface waters (0.07 to 0.55 mg/l/day) and bottom waters (0.06 to 0.42 mg/l/day) of the study region indicate that these waters are within the primary water quality criteria and do not pose any threat to the environment under present condition.

The total suspended matter (TSM) ranged from 17.4 mg/l to 45.6 mg/l in the surface and from 16.8 to 36.7 mg/l in bottom waters of the study region. Normally bottom waters experience high suspended sediments because of bottom turbulence and churning of the sediments.

Nutrients play a vital role in the biogeochemical cycles in the marine environment. Owing to their key role in phytoplankton productivity, which in turn triggers the transfer of energy and material from their source in a physical environment to biological environment and vice-versa, study of nutrients always occupied a key position in hydro chemical and biological investigations.

Nitrite represents the most unstable form of dissolved inorganic nitrogen present in seawater because it can be formed as an intermediate product during the regeneration pathways of nitrification and denitrification. Again, it is often released as extra cellular products from planktonic organisms altering its concentration in the ambient medium (Santchi *et al.,* 1990). Accordingly, the nitrite content in marine ecosystem exhibits well marked variation in spatio-temporal scale. The concentrations of nitrite (NO_2 -N) in surface and bottom waters varied between 1.7-8.5 μg/l and 1.6- 6.5 μg/l, respectively. Mean nitrite values were found to be similar in the surface (4.6 μg/l) and bottom (4.3 μg/l) waters during the study period.

Nitrate is thermodynamically most stable from of inorganic nitrogen present in oxygenated seawater. The nitrate content in sea water is governed by three important factors namely, its input through riverine transport and subsequent mixing of the riverine water with sea water, phytoplankton uptake and replenishment by the

decomposition of organic matter. The nitrate values ranged between 21.3 to 62.7 μg/l in the surface and from 21.5 to 53.7 μg/l in the bottom waters. The range of nitrate values found in this study is consistent with the range of values observed in the adjacent coastal waters of east coast of India.

Ammonium (NH_4 - N) varied from 9.1 to 45.9 μg/l in the surface and from 0.3 to 42.1 μg/l in the bottom waters of the study region. Highest concentrations of ammonium was noticed at the marine outfall location (MOP). High concentrations of nitrogen compounds (both inorganic and organic) may be due to land runoff and other discharges.

In tropical marine ecosystems phosphate is considered as the most important nutrient limiting phytoplankton production. The phytoplankton assimilation of phosphate is always considered as an important factor for its spatio-temporal variations in a marine milieu. Inorganic phosphate (PO_4 -P) is in the range of 14.3-44.4 μg/l and 27.2- 47.2μg/l in the surface and bottom waters, respectively. Relatively higher concentrations of phosphate was observed in the bottom than the surface waters, may be due to its removal by phytoplankton assimilation in the surface and/or addition by decomposition of organic matter in the bottom.

Silicate is considered as an important source of nutrient for phytoplankton productivity, when the plankton community is dominated by diatoms, silicoflagellates or radiolarians. The entry of silicate into the sea mainly takes place through land drainage, rich with weathered silicate material. Therefore, silicate contents in coastal waters always remain higher than the offshore areas, particularly so in upper few meters. Further, adsorption of reactive silicate onto suspended sediments and chemical interaction with clay minerals greatly influence the silicate distribution. Silicate - Silicon (SiO_4 - Si), concentrations ranged from 139 to 277 μg/l and 207-435 μg/l in surface and bottom waters respectively. Significantly higher mean concentration of silicate was found in bottom waters (285 μg/l) than that of the

surface waters (197μg/l) during the study period. It could be due to the influence of biological processes as described above for phosphate.

The majority of oil entering the marine environment originates from land based sources including coastal refineries, municipal and industrial waste-water discharges, urban runoff and river flow. Thus there is an essential need to check these constituents in the coastal environment under study. The concentrations of Petroleum hydrocarbons of the study area are shown in Table 2.1. Petroleum hydrocarbons ranged from 1.3 to 10.5 μg/l in the surface and from 1.7 to 4.7 μg/l in the bottom waters of the study region. No much variation is found in the concentrations of PHC between surface and bottom waters and, are well within the normal limits of coastal waters.

The results of the three monitorings and the baseline data (Table 2.3) in the marine environment were compared to know the impact of treated effluents due to discharge. The ranges of the concentrations of chemical constituents are in the threshold limits of coastal environment. High nutrients, high salinity and low DO in the bottom waters of the present monitoring indicate stratification of waters. Similar conditions were observed off Kakinada during this study period However, there is no stress or threat to the marine environment even after the discharge of treated effluents at present. However periodic monitoring of the marine environment is a mandatory for the industry.

Table 2.1 Concentrations of Physico-chemical parameters in the study area during April 2017

STATION NAME	DEPTH	TEMP (°C)	Salinity	DO (mg/l)	BOD (mg/l)	Phenol (µg/l)	pH	TSM (mg/l)	PHC (µg/l)
NKP-1	Sur	29.5	33.03	4.5	0.09	4.0	7.5	17.4	2.0
	Bot	26.8	34.42	4.6	0.40	12.6	7.5	-	1.9
NKP-2	Sur	30.0	34.38	2.7	0.56	2.4	7.4	27.1	1.3
	Bot	25.7	34.63	3.3	0.10	4.1	-	18.3	3.4
NKP-3	Sur	28.7	34.35	3.5	0.07	3.1	7.5	45.6	10.5
	Bot	26.9	34.37	4.9	0.09	2.2	7.6	24.8	2.0
NKP-5	Sur	28.7	33.03	4.5	0.42	5.6	8.0	18.5	3.4
	Bot	25.9	34.41	5.5	0.39	4.1	8.0	36.7	2.6
NKP-6	Sur	28.7	32.92	5.0	0.08	3.4	8.0	21.3	1.8
	Bot	26.7	34.43	5.0	0.06	-	8.0	16.8	4.7
NKP-7	Sur	28.4	34.35	5.7	0.09	2.1	7.7	19.3	3.5
	Bot	26.1	34.50	3.9	0.42	7.6	7.7	-	2.8
NKP-8	Sur	28.5	34.31	6.0	0.36	2.1	7.5	22.9	4.5
	Bot	26.1	34.40	4.5	0.22	5.4	8.0	21.1	4.0
NKP-9	Sur	28.4	34.06	6.0	0.08	4.8	8.0	20.9	6.3
	Bot	26.5	34.37	3.7	0.07	-	8.0	-	1.7
NKP-10	Sur	28.3	34.36	6.0	0.11	-	7.7	19.8	0.0
	Bot	26.6	34.43	5.9	0.08	-	7.6	20.1	1.7
NKP-MOP	Sur	28.9	34.06	5.3	0.11	2.3	-	17.6	2.6
	Bot	26.9	34.39	4.7	0.12	1.5	7.6	18.7	4.5

Sur = Surface **Bot =** Bottom

DO = Dissolved Oxygen **BOD =** Biological Oxygen Demand

TSM =Total Suspended Matter **PHC =** Petroleum Hydrocarbons

Table 2.2 Concentrations of nutrients in the study area (April 2017)

Station Name	Depth	Ammonium (µg/l)	Nitrite (µg/l)	Nitrate (µg/l)	Phosphate (µg/l)	Silicate (µg/l)
NKP-1	Sur	26.3	1.7	40.8	32.9	182
	Bot	23.5	4.1	21.5	27.2	429
NKP-2	Sur	9.1	3.8	46.0	44.4	140
	Bot	6.0	6.5	22.6	37.2	438
NKP-3	Sur	23.7	3.4	36.7	28.6	218
	Bot	28.1	1.6	23.5	30.1	259
NKP-5	Sur	16.4	4.8	38.5	36.4	243
	Bot	15.3	3.1	53.7	34.8	207
NKP-6	Sur	24.4	4.3	62.7	27.9	139
	Bot	20.3	3.4	44.2	35.9	213
NKP-7	Sur	21.4	3.2	50.3	22.9	195
	Bot	22.2	5.7	46.9	33.1	274
NKP-8	Sur	39.8	8.5	48.7	22.9	207
	Bot	25.0	5.4	50.3	38.5	216
NKP-9	Sur	20.6	6.0	54.3	30.2	277
NKP-10	Sur	23.6	6.2	32.2	14.3	183
	Bot	0.3	5.8	53.3	38.6	276
NKP-MOP	Sur	45.9	4.5	21.3	41.5	186
	Bot	42.1	3.2	25.4	47.2	250

The results of the physic-chemical parameters of the present study were compared with those obtained during the earlier monitoring studies conducted in 2012 and 2014, and also compared with the base line data obtained during 2007 and 2010 in the study region. The range of values for all physico-chemical parameters found in this study is well within the range of values found within the coastal waters of east coast on India, and no significant deviation in the seawater quality of the study region was found compared to the adjacent coastal waters.

Table 2.3 Comparison of chemical constituents in the marine environment during three different monitorings

	2007	2010	2012	2014	2017
Parameter	**Range**	**Range**	**Range**	**Range**	**Range**
D.O (mg/l)	5.09-6.65	3.24-5.58	5.64-7.58	2.26-5.22	2.7-6.0
BOD (mg/l)	0.29-1.16	0.13-1.54	0.06-0.86	0.07-0.55	0.06-0.42
pH	7.9-8.1	8.0-8.1	8.1-8.2	7.4-8.0	7.4-8.0
TSM (mg/l)	10.6-35.2	34.2-69.6	19.0-32.8	16.4-48.8	16.8-45.6
NO_2-N (µg/l)	0.6-4.3	1.4-10.4	0.6-6.8	8.2-17.8	1.6-8.5
NO_3-N (µg/l)					21.3-62.7
NH_4-N (µg/l)	13.8-52.4	4.90-41.02	12.1-34.0	22.4-35.6	6.0-45.9
PO_4-P (µg/l)	8.37-40.46	2.88-33.28	27.6-75.3	42.8-131.8	14.3-47.2
SiO_4-Si (µg/l)	23-156	20-202	101-381	289-406	139-438

Chapter 3
BIOLOGICAL STUDIES

3.1. Introduction

The coastal water is extensively used for the exploration and exploitation of marine resources. These areas are being used for dumping industrial and domestic wastes. Industrialization and urbanization of these areas has also seen a parallel protest by local communities against the potential damage caused by the coastal development to marine ecology. The deterioration of ecology is seen as a threat to living creature of the area. Therefore, monitoring of biological data of an aquatic ecosystem becomes a necessity in the environmental impact assessment.

The biological communities are the best indicators of environmental quality of an area. The microorganisms, particularly the bacteria, contribute substantially to the productivity of the ecosystem. The planktonic organisms are of great ecological significance as they constitute the major part of the primary production. They are cosmopolitan in distribution and play important role in the marine food web. They form the main food for fishes and hence their abundance and distribution in the water column is indicative of fishery resources. Benthic organisms are the important component of secondary production of the aquatic ecosystem. It is believed that the ecosystem reacts to any anthropogenic activity in the coastal areas that can be assessed by collecting systematic data on biological parameters. Hence It is imperative to collect data on different trophic levels of the biological resources of a target area for a reasonable assessment of the environmental quality . In the present report, the overall status of the various biological components and their diversity studied from study area off Nakkapalli coast, are presented.

3.2 Sampling and analysis

For the study of biological parameters all the11 stations in the study region (Fig. 2.1) were sampled for microbiology, phytoplankton, zooplankton and benthos

during the field campaign conducted on 17th April 2017. The details of stations positions are given in Table 3.1. Collection of samples for zooplankton by towing the net and collection of zooplankton samples from the net bucket were shown in figures 3.1 and 3.2 respectively. Similarly, collection of surface sediment samples for benthos using Van Veen Grab sampler were shown in figures 3.3 – 3.6. The specific tasks included collection of water samples for microbiology, phytoplankton (cell count and generic diversity) zooplankton (standing stock population and faunal groups) and benthos (macrobenthic biomass, population count and faunal diversity) using standard protocols were given below.

Fig. 3.1: Towing of zooplankton net

Fig. 3.2: Zooplankton sample collection

Fig. 3.3: Van Veen Grab Sampler

Fig. 3.4: Operation of Van Veen Grab sampler

Fig. 3.5: Collection of sediment sample

Fig. 3.6: Sediment sample

3.2.1 Microbiological Studies

Altogether a set of 22 water samples from 11 stations were analyzed for this study. One hundred milliliters of sample from each location was collected in to Pre-sterilized bottles. All samples were collected with precautions required for microbiological analysis held on ice in an icebox and transported to the laboratory for further analysis. Samples were analyzed for Total viable count (TVC), Total *coliform* count (TCC),*Vibrio* like organisms (VLO) and *Salmonella* like organisms.

All the media were prepared with the addition of aged seawater and autoclaved. All the Medias used are from Hi Media. TVC, TCC, VLO and SLO were isolated on Nutrient agar, Mac.Conkeys agar,*Vibrio* agar and *salmonella* agar respectively. All plates were prepared 2 days prior to sampling. Aliquots of 0.1 ml of water samples were spread plated in duplicate on nutrient agar plates prepared at least 2 days prior to plating. And aliquots of 0.2 ml of water samples were spread plated on all other selective Media mentioned above. These volumes spread on to the medium in 90 mm diameter plates were easily absorbed without any trace of liquid. All the plates were incubated at room temperature (28±0.5 °C) at least for 24 to 48 h and final counts of colonies were noted.

Surface water samples were collected with sterile glass stoppered bottle and bottom samples were collected with a Nansen sampler. All samples were stored in ice immediately after collection and transferred to the field laboratory for enumeration of different groups of bacteria. Standard microbiological methods were followed for dilution, surface plating and incubation.

All analyses were carried out within a few hours of collection. Water samples were directly used as inocula and samples were serially diluted to give countable numbers expressed as number/ml of water. Surface plating technique was used and counting of plates were carried it after 48 -72 hours of incubation at ambient temperature.

3.2.2 Phytoplankton

Distribution and abundance of phytoplankton in the coastal waters of proposed site were examined. The water samples were collected by Niskin water samplers from all stations and 1 litre water samples were preserved with Lugol's Iodine solution. The fixed and preserved samples were transported to laboratory for identification and counting of phytoplankton. Samples were settled in 24hrs without disturbances before the analysis. The supernatant was siphoned out though the small tube contains the 20µm mesh in one end and the final volume was made to 20ml. One ml of this was counted using Sedwig's rafter, under inverted microscope. Total cells were counted and organisms were identified using standard manuals of Diatoms, Dinoflagellate and Blue green algae. The counts were expressed on per litre basis for comparison. The species were identified after Subrahmanyam (1946) and Carmelo (1997).

3.2.3 Zooplankton

Zooplankton samples were collected through horizontal hauls of WP-2 net (50 cm diameter and 200 µm mesh) attached with the calibrated digital flow meter to measure the amount of water filtered through the net. At each station, the net was operated for 5 minutes and the collected samples filtered through the 200 µm mesh and the excess waters were removed using the bolting paper and the zooplankton biomass was measured through the displacement method (Postel et al., 2000). After the biomass measurements, zooplankton samples were preserved in 4-5 % buffered formaldehyde for further analysis. In the laboratory, 25 - 50%subsamples were taken using the Folsom's plankton splitter and the subsamples were analyzed in detailed for quantitative analysis. Zooplankton samples were sorted into group levels using the standard literatures of the Conway et al., 2000 and their abundances were represented in m^3.

3.2.4 Benthos

Benthic investigations consisted of collection of seabed samples from all 11 locations. Samples were collected with the help of a van Veen grab (0.1 m^2). In general, 0.5 mm sieve was used for separating macro benthos and washing the sediment with copious seawater. Sieving was carried out onboard. After sieving, the fauna (live animals) were carefully separated and together with residual sediment, if any, the samples were fixed in 5% (neutral) formaldehyde-rose Bengal solution, labeled and, stored for further examination. In the laboratory, the sediments were washed again under tap water and the material preserved in 5% formaldehyde or denatured spirit containing Rose Bengal stain. For qualitative enumeration, each sample was examined under a binocular microscope. The organisms were separated into different taxonomic groups for further identification. All taxa were identified as far as possible with the help of standard taxonomic references. Plychaetes were identified by following Day (1967).

For meiofauna sampling, sub-samples were taken from undisturbed grab samples with the help of a core tube of 4.5 cm inner diameter. All samples were passed through a set of two sieves. The top one is of 0.5 mm mesh screen and the lower one is of 0.062 mm mesh. Animals retained on the lower screen were considered for meiofauna. Samples were preserved in formalin Rose Bengal solution. Animals were identified to taxa level and counted under microscope. The counts are presented as numbers per 10 cm^2.

3.3 Results

The Bay of Bengal, harbour a variety of ecosystem and habitats, such as estuaries; mangroves; intertidal foreshore-rocky, sandy and muddy areas; coastal lagoons and backwaters; coral reefs and patchy corals; seagrass beds; continental and deltic islands; neritic and oceanic regions extending through bathyal, abyssal and hadal depths. The present study area falls in the coastal Andhra Pradesh of central east coast. It has rich coastal biodiversity due to the presence of important rivers

such as Godavari and Krishna. The coastal segments covering mangrove forests, open banks, sandy patches, mud flats and backwaters form the rich faunal and floral system of the state. The annual overall biological productivity of there ecosystem varies widely as evident from the following data:

Ecosystem	**Annual productivity ($gC/m^2/y$)**
Estuaries	300-850
Mangroves	350-500
Lagoons and mudfalts	580-860
Coral reefs	2000-5000
Seagrass beds	500-3000
Neritic areas	120-800
Oceanic areas	20-50

3.3.1 Microbiology

The result of the study on microbiology is presented in Table 3.2. All the values have been reported as colony forming unit per ml (CFU/ml x 10^3). Control plates were kept to check for any contamination with spreaders or in working area. Viable counts in surface water were in the range of 5.6-13.6 x10^3 CFU/ml while in bottom water it varied from 3.2 – 33.0 x10^3 CFU/ml. The coliforms ranged from 0.3 – 0.8x10^3 CFU/ml in surface water and 0.2-1.2x10^3 CFU/ml in the bottom waters. *E.coli* were counted in samples collected from the study region and their number ranged from 1.5-3.7 x10^3 CFU/ml and 0.7-7.4x10^3 CFU/ml in the surface and bottom waters, respectively. Generally the bacterial counts were relatively lower in surface water than in bottom water. The count of all the parameters is well within normal range for a typical coastal water.

3.3.2 Phytoplankton

The distribution of dominant phytoplankton genera in the offshore, near shore and estuarine waters of the Bay of Bengal is given below. The most dominant families to which these species belonged to are Bacillariophyceae, Cyanophyceae and dinophyceae.

OFFSHORE	NEARSHORE	ESTAURY
Nitzschia ,Navicula	*Nitzschia*	*Nitzschia*
Chaetoceros	*Trichodesmium*	*Synedra*
Thallassiosira	*Chaetoceros*	*Skeletonema*
Pleurosigma	*Bacteriastrum*	*Navicula*
Trichodesmium	*Rhizosolenia*	*Chaetoceros*
Coscinodiscus	*Navicula*	*Pleurosigma*
Bacteriastrum	*Pleurosigma*	*Rhizosolenia*
Rhizosolenia	*Thallassiosira*	*Surirella*
Peridinium	*Coscinodiscus*	
Synedra	*Synedra*	
	Melosira	

Numerical abundance: Altogether 22 samples collected from surface and bottom were analyzed for phytoplankton species composition and abundance. The phytoplankton cell counts in the coastal waters of Rajayyapeta are given in Table 3.3 and 3.4 for surface and bottom waters respectively. The numerical abundance ranged from 5430 to 15390 No/L in surface water whereas from 5820 to 18330 No/L in the bottom water. Total number of genera recorded in the surface water varied 12-19 in surface waters and 15 -22 in the bottom waters.

Species composition and diversity: The majority of the phytoplankton taxa belonged to diatoms. The important genera of phytoplankton were *Cheatoceros* , *Nitzschia sp., Pseudo-nitzschia* , *Rhizosolenia* sp., *Skeletonema , Navicula*

Thalassionema Thalassiosira Thalassiothrix Coscinodisus and Guinarida. The diversity was comparable in surface and bottom waters. The genera represented were of coastal waters. The highest diversity was recorded at Station NKP 10 in surface and bottom waters.

Phytoplankton data obtained in this study were compared with data obtained during earlier monitoring conducted in the years 2012 and 2014 in the present study region.

A comparison of phytoplankton data with earlier studies is given below.

Year		No of species (range)	Cell Counts (no/l)
2012	S	11-17	200-4800
	B	7-14	100-2900
2014	S	6-20	2400-16600
	B	7-13	3600-18000
2017	S	12-19	5430-15390
	B	15-22	5820-18330

S=surface B=bottom

The cell counts and number of species recorded in 2017 was significantly higher than in 2012 and 2014. This could due to seasonal variation.

3.3.3 Zooplankton Composition and abundance

Standing stock or biomass (ml/m^3) of zooplankton in the Bay of Bengal shows wide variation in space and time in the shelf as well as the oceanic ecosystems of Bay of Bengal and the details are as follows:

Season	Bay of Bengal	
	Shelf	Oceanic
Premonsoon	< 0.01-1(0.3)	0.01-0.8(0.3)
Monsoon	0.1-3.3(0.4)	0.1-0.5(0.2)
Postmonsoon	<0.1-3.6(0.5)	0.1-5.3(0.8)

Zooplankton represents secondary productivity of the marine food chain. The seasonal average of zooplankton biomass for the Bay of Bengal is 0.43 ml/m^3 in pre-monsoon, 0.24 ml/m^3 in monsoon and 0.99 ml/m^3 in post-monsoon season (Desai & Bhargava, 1998). The secondary production has been estimated to be 9.3 mgC/m^2 /d for the Bay of Bengal, with the annual production rate of 1.77x10^6 tC/y.

Major groups of zooplankton and their percentage contribution in the offshore and near shore regions of Bay of Bengal are summarized below.

MAJOR GROUP	OFFSHORE(%)	NEARSHORE(%)
Copepods	72.0	66.3
Chaetognaths	4.3	9.6
Decapod larvae	1.0	8.7
Lamellibranchs	6.5	4
Gastropods	7.4	1.5
Siphonophores	2.1	2.2
*Lucifer*sp	-	2.9
Fish eggs/larvae	-	2.4
Ostracods	1.4	-
Pteropods	1.1	-
Amphipods	1.0	-
Foraminiferans	1.0	-
Polychaetes	0.4	-
Cladocerans	-	1.0

Distribution and biomass: The distribution and abundance of zooplankton in the study area is given in Table 3.5. A total of 15 different taxa including larvae were recorded in the samples collected from 11 stations, of which one taxa was recorded from all stations. The numerical counts of different taxa recorded in the study area varied between 500 to 3239 Ind/m^3 while the biomass was in the range of 0.03 to 0.41 ml/m^3 . The percent contribution of various groups to the total zooplankton community was given in Table 3.6. The overall picture of the zooplankton of the study area suggest that the composition and biomass were moderately high. The most dominant taxa recorded was copepod, and contributes 75.8 to 94.3% in the total abundance. In general the quantitative data on zooplankton is a suggestive of typical of coastal waters which is known to undergo strong seasonal variation in abundance and diversity.

A comparison of present set of data on zooplankton with earlier studis is presented in the below table.

Year	Numerical count (no/100m^3)	Biomass (ml/100m^3)
2012	2440 -13202 (5666)	0.01 – 0.43 (0.10)
2014	3395 -16855 (9765)	3.6 – 11.4 (7.07)
2017	50000 – 323900 (177600)	3.0 – 41.0 (17.0)

It is clear from the quantitative data that the zooplankton abundance and biomass was very high which may be attributed to inter annual variability.

3.3.4 Benthos

3.3.4.1 Composition and abundance of macrofauna:

The macrofauna off Rajayyapeta in the depth zone of 10-16 m is given in Table 3.7. The macrobenthic organisms comprised of three major groups of *polychaeta, Arthropoda*, and *mollusca*. The minor phyla also contributed substantially to the total density of macrobenthos. About 18 polychaete forms were identified among which *Nephtyidae, Spionidae, Glyceridae,* wereregularly recorded from most of the stations. Some of the species like *Cossuracoasta Heteromastus* sp. and *Prionospiopinnata* are the indicators of organic enrichment particularly of shallow region and were recorded from some stations. The polychaetes contributes >50% in total abudance. Mollusca was represented by bivalves only. A good portion of density was formed by minor phyla such *sipuncula, nemertina, Echiurid worm nematoda* and *brachiopoda*.

The population density of macrofauna ranged from 900 to 4650 individuals/m^2. Among 11 stations studied, NKP 8 recorded the highest density while NKP9 recorded lowest density. The total wet weight biomass was in the range of 1.215 g/m^2 at NKP2 to 8.985 g/m^2. Polychaetes are the major contributor to the wet weight biomass.

Diversity: The macrobenthos diversity was determined based on the two indices namely, Shanon Wiener (H') and the evenness component (J). The result is given in Table 3.8. The total number of species/taxa ranged from 9 to 19. The species evenness was in the range of 0.58 at NKP2 to 0.95 at NKP9. The species diversity (H') was in the range of 1.33 at NKP2 to 2.52 at NKP8. A comparison of present data with that of 2012 is given below. It revealed no significant difference

Year	No of species	Density (no/m2)	Biomass (g/m2)	Diversity
2012	**11-21**	**400-2575**	**2.25-12.6**	**1.16-2.77**
2014	**3-20**	**125-3325**	**0.25-13.28**	**1.05-2.43**
2017	**9-19**	**900 – 4650**	**1.22 – 8.99**	**1.33 – 2.52**

.3.3.4.2 Meiofauna

The meiofaunal density (No. /10cm^2) is given in Table 3.9. Total count of meiofauna was in the range of 416 and 1006 No/10cm^2 with a mean value of 661 $\pm$186/10cm^2. Maximum abundance was recorded at NKP4 and minimum at NKP8. A total of ten metazoan groups were recorded from the 11 sampling stations. Nematodes were the most dominant group with numerical density of 311-710/10cm^2. The percent composition of nematode was >80% at all stations. The *turbellarians* were next in the order of abundance with density range of 22-160/10cm^2, followed by benthic *harpacticoida* and *polychaeta*. Two groups, the nematode and turbellaria were recorded from all stations. The other important groups were identified ostracoda, foraminifera, crustacean nauplii and tardigrada. The important feature of the meiofauna was consistent occurrence of crustacean *nauplii* in the samples.

Effect of project activities on biology: A comparison of biological data obtained in the present study (2017) with results of earlier monitoring conducted in the same region during 2012 and 2014 revealed that there is no significant change in the biological characteristics of the regions. Hence, it is concluded that the effluent discharged from M/s Hetero Drugs into the sea through a diffuser has no significant adverse impact on ecology of the region.

Table 3.1: Geographical location of station positions off Rajayyapeta

Station Name	Geographical Location	Station Name	Geographical Location
NKP1	17°21'35.96"N	NKP6	17°20'9.73"N
	82°45'30.65"E		82°45'3.50"E
NKP2	17°21'20.18"N	NKP7	17°20'58.64"N
	82°45'1.42"E		82°44'16.02"E
NKP3	17°21'13.57"N	NKP8	17°20'50.34"N
	82°44'45.82"E		82°44'1.25"E
NKP4	17°20'52.57"N	NKP9	17°20'34.85"N
	82°44'39.19"E		82°43'31.44"E
NKP5	17°20'38.20"N	NKP10	17°21'20.27"N
	82°44'47.58"E		82°44'20.98"E
NKP-OFP		17°21'6.96"N; 82°44'30.96"E	

Table 3.2: Microbiology data off Rajayyapeta

Station Name	TVC (CFU x 10^3/ml)		TC (CFU x 10^3/ml)		ECLO (CFU x 10^2/ml)	
	Sur	Bot	Sur	Bot	Sur	Bot
NKP 1	6.4	3.2	0.4	0.2	1.7	0.7
NKP 2	13.2	10.1	0.8	0.6	3.6	2.3
NKP 3	7.5	10.6	0.4	0.6	2.0	2.4
NKP 4	10.3	12.3	0.6	0.7	2.8	2.8
NKP 5	12.1	7.7	0.7	0.5	3.3	1.7
NKP 6	8.5	14.8	0.5	0.9	2.3	3.3
NKP 7	5.6	11.5	0.3	0.7	1.5	2.6
NKP 8	11.3	33.0	0.7	1.2	3.1	7.4
NKP 9	9.2	11.6	0.5	0.7	2.5	2.6
NKP 10	9.7	13.8	0.6	0.8	2.6	3.1
HTR MOP	13.6	17.7	0.8	1.1	3.7	4.0

Table 3.3: Phytoplankton abundance (No/L) in surface waters of the study region

Sl No	Species	NKP1	NKP2	NKP3	NKP4	NKP5	NKP6	NKP7	NKP8	NKP9	NKP-10	NKP-OFP
1	*Amphiprora* sp.	0	0	0	0	0	60	0	0	0	0	0
2	*Amphora* sp.	0	0	90	50	0	0	0	0	0	0	0
3	*Asterionella* sp.	270	600	690	720	390	150	0	510	840	630	510
4	*Bacillaria* sp.	0	0	0	0	0	0	0	0	0	0	150
5	*Bacteriastrum*sp.	0	60	120	100	120	60	90	150	90	90	0
6	*Bellerochea* sp.	0	0	0	0	0	0	0	0	0	120	120
7	*Biddulphia*Sp.	0	0	0	0	0	0	0	0	60	0	0
8	*Ceratualina* sp.	0	630	480	600	720	90	510	360	390	0	240
9	*Cheatoceros*sp.	240	690	420	580	450	0	1740	990	0	420	330
10	*Coscinodisus* sp.	270	270	300	300	90	0	330	150	210	180	240
11	Cynobacteria filaments	0	0	390	200	120	0	90	60	0	0	90
12	*Cynobacteria*sp.	0	60	30	50	0	0	0	0	0	60	30
13	*Dactyliosolenia* sp.	0	0	120	120	90	0	0	60	0	0	60
14	*Diploneis*sp.	60	0	0	0	0	0	0	0	0	0	0
15	*Eucampia* sp.	0	30	0	20	90	0	0	0	120	0	0
16	*Gryrosigma* sp.	0	0	0	0	0	0	0	90	0	0	0
17	*Guinarida*sp.	0	90	660	410	510	480	960	360	540	150	330

Table 3.3: Phytoplankton abundance (No/L) in surface waters of the study region *continued*

18	*Hemiaulus* sp.	0	0	0	0	60	0	0	0	0	0	0
19	*Lauderia*sp.	0	180	0	100	0	0	90	210	180	120	120
20	*Leptocylindrus* sp.	0	60	0	30	0	0	120	0	180	0	0
21	*Melosira* sp.	300	0	0	0	0	0	30	0	0	120	0
22	*Navicula* sp.	120	90	150	120	240	150	0	60	150	150	150
23	*Nitzschia*sp.	1710	1710	1830	1600	1590	840	1620	1110	1530	1590	1260
24	*Paralia* sp.	0	0	0	0	660	0	0	150	240	0	0
25	*Pleurosigma*sp.	0	60	0	30	60	0	0	0	0	90	0
26	*Pseudo-nitzschia* sp.	3690	5010	5250	3700	3420	2850	6690	2130	3780	5160	3300
27	*Rhizosolenia* sp.	1080	1050	1350	800	1080	420	1770	1800	1290	1380	1020
28	*Skeletonema*sp.	690	180	0	100	0	0	240	0	540	120	540
29	*Synedra* sp.	0	0	0	0	0	0	90	0	0	30	0
30	*Thalassionema* sp.	300	330	1290	300	180	240	480	420	1620	390	1110
31	*Thalassiosira*sp.	240	0	120	50	40	90	450	0	150	210	0
32	*Thalassiothrix* sp.	90	0	180	100	0	0	0	60	150	0	360
33	Unknown	90	150	90	60	60	0	90	0	0	180	0
	Total	9150	11250	13560	10140	9970	5430	15390	8670	12060	11190	9960
	Chlorophyll *a*	1.11	2.45	2.54	2.34	2.12	0.95	2.81	1.17	2.64	1.64	1.45

Table 3.4: Phytoplankton abundance (No/L) in bottom waters of the study region

Sl. No	Species	NKP1	NKP2	NKP 3	NKP 4	NKP 5	NKP6	NKP7	NKP8	NKP 9	NKP 10	NKP-OFP
1	*Amphiprora* sp.	180	60	0	120	0	0	120	60	90	0	0
2	*Amphora* sp.	0	300	0	150	0	0	0	0	90	0	30
3	*Asterionella* sp.	270	480	1710	300	450	750	930	300	300	1620	510
4	*Bacteriastrum*sp.	0	0	0	0	120	0	0	0	0	0	0
5	*Bellerochea* sp.	0	0	120	0	270	0	0	0	0	90	0
6	*Biddulphia* sp.	0	0	0	0	120	0	0	0	60	0	0
7	*Ceratualina* sp.	210	120	540	120	900	240	0	0	0	390	30
8	*Cheatoceros* sp.	0	120	810	60	2700	300	720	0	450	1620	720
9	*Corethron* sp.	0	0	0	0	0	0	0	0	0	60	0
10	*Coscinodisus* sp.	240	120	330	180	330	150	240	150	180	240	60
11	Cynobacteria filaments	0	0	0	0	120	0	0	0	0	0	0
12	*Dactyliosolenia* sp.	0	150	120	60	120	0	0	0	60	180	0
13	*Diploneis* sp.	60	90	0	90	0	0	90	0	60	120	0
14	*Ditylum* sp.	90	0	0	0	0	60	0	0	0	0	0
15	*Gryrosigma* sp.	0	0	0	0	0	60	0	60	0	0	0
16	*Guinarida* sp.	0	210	540	90	1380	360	0	0	420	210	390
17	*Hemiaulus* sp.	0	0	0	0	0	0	0	60	0	0	0

Table 3.4: Phytoplankton abundance (No/L) in bottom waters of the study region *continued*

18	*Lauderia* sp.	330	360	180	360	480	210	300	0	150	120	0
19	*Leptocylindrus* sp.	0	0	0	0	0	0	120	180	0	0	90
20	*Melosira*sp.	0	0	0	0	60	0	0	0	0	480	90
21	*Navicula* sp.	180	180	210	180	300	0	180	0	720	270	90
22	*Nitzschia* sp.	1380	330	2580	720	2220	1650	1170	570	510	1710	2700
23	*Paralia*sp.	3300	2130	1290	2900	360	300	1620	1140	0	960	300
24	*Pinnularia* sp.	0	30	0	0	0	0	0	0	0	0	0
25	*Planktoniella* sp.	60	0	0	30	0	0	0	0	0	0	0
26	*Pleurosigma* sp.	90	210	90	150	0	0	240	270	210	180	60
27	*Pseudo-nitzschia* sp.	2520	330	3330	1320	4380	2790	1770	2280	1050	1320	3690
28	*Rhizosolenia* sp.	780	360	750	480	1800	1230	600	900	240	840	390
29	*Skeletonema*sp.	0	0	0	0	1170	0	0	0	0	0	120
30	*Stephanophysis*sp.	0	30	0	0	30	0	30	450	0	0	0
31	*Synedra* sp.	120	60	0	90	60	0	0	0	30	0	120
32	*Thalassionema* sp.	1530	2220	1290	1710	750	780	630	720	930	870	180
33	*Thalassiosira* sp.	0	0	180	0	0	0	0	0	0	330	270
34	*Thalassiothrix* sp.	120	0	300	60	0	60	90	120	0	300	0
35	Unknown	60	90	180	60	210	120	120	180	270	60	90
	Total	11520	7980	14550	9230	18330	9060	8970	7440	5820	11970	9930
	Total Chl.*a*	2.42	2.70	3.58	2.4	3.03	2.96	2.12	2.45	1.64	2.34	2.4

Table 3.5: Zooplankton abundance (No/m^3) and biomass (ml/m^3) in surface waters of the study region

Sl No		NKP1	NKP2	NKP3	NKP 4	NKP5	NKP6	NKP7	NKP8	NKP9	NKP10	NKP-OFP
1	Hydromedusae	0	0	0	2.464	1.632	0.972	0	0.476	1.28	1.02	0
2	Siphonophore	0.26	0.374	0.378	1.276	2.057	1.092	0	0	0	0.3	0.896
3	Thaliacea	0	0	29.7	5.5	10.71	58.8	23.8	67.2	32.4	0	14.7
4	Chaetognatha	0.8	1.2	7.1	1.4	2.1	1.1	3.8	4.1	1.7	2.1	4.5
5	Copepods	726	594	397	3047	2099	2446	864	870	1099	2369	2286
6	Cladocerans	1.96	3.74	1.224	0	0.255	0	0.323	0	0.48	0	0
7	Ostracods	2.42	2.728	0	10.78	5.44	0.192	39.1	0	0	0	0
8	Lucifers	0	3.74	4.32	0	0	19.92	0	0	0	0	5.6
9	Appendicularians	10.2	53.24	21.42	37.84	172.72	148.2	3.91	33.88	28	137.8	56
10	Polychaete larvae	3.3	2.51	4.32	0	2.52	0	2.06	6.72	0	0	2.37
11	Decapod larvae	4.3	7.68	3.56	10.78	4.27	7.08	26.35	4.62	2.24	5	4.37
12	Bivalve larvae	1.9	2.464	1.764	3.63	0	49.44	38.38	61.04	56	24.6	56
13	Gastropod larvae	3.38	3.74	10.26	26.62	21.59	84.72	30.39	61.04	168	177.2	39.06
14	Fish Eggs	15.2	11.44	8.46	81.18	10.71	10.56	15.81	33.88	0	93.6	229
15	Fish larvae	0	37.4	10.8	11	2.72	34.8	3.06	4.76	4.2	2.7	2.52
	Total (No.m^{-3})	769	724	500	3239	2336	2863	1051	1147	1393	2813	2700
	Biomass (ml.m^{-3})	0.04	0.03	0.04	0.19	0.32	0.41	0.11	0.16	0.17	0.15	0.25

Table 3.6: Percentages of contribution of various groups in total zooplankton abundance

No	Groups	NKP1	NKP2	NKP3	NKP- 4	NKP5	NKP6	NKP7	NKP8	NKP9	NKP10	NKP-OFP
1	Hydromedusae	0	0	0	0.08	0.07	0.03	0	0.04	0.09	0.04	0
2	Siphonophore	0.03	0.05	0.08	0.04	0.09	0.04	0	0	0	0.01	0.03
3	Thaliacea	0	0	5.94	0.17	0.46	2.05	2.26	5.86	2.33	0	0.54
4	Chaetognatha	0.1	0.17	1.42	0.04	0.09	0.04	0.36	0.36	0.12	0.07	0.17
5	Copepods	94.32	82	79.35	94.06	89.86	85.44	82.22	75.8	78.88	84.21	84.66
6	Cladocerans	0.25	0.51	0.25	0	0.01	0	0.03	0	0.03	0	0
7	Ostracods	0.31	0.38	0	0.33	0.23	0	3.72	0	0	0	0
8	Lucifers	0	0.52	0.86	0	0	0.69	0	0	0	0	0.21
9	Appendicularians	1.33	7.35	4.28	1.17	7.4	5.18	0.37	2.95	2.01	4.9	2.07
10	Polychaete larvae	0.43	0.35	0.86	0	0.11	0	0.2	0.59	0	0	0.09
11	Decapod larvae	0.56	1.06	0.71	0.33	0.18	0.25	2.51	0.4	0.16	0.18	0.16
12	Bivalve larvae	0.25	0.34	0.35	0.11	0	1.73	3.65	5.32	4.02	0.87	2.07
13	Gastropod larvae	0.44	0.52	2.05	0.82	0.92	2.96	2.89	5.32	12.06	6.3	1.45
14	Fish Eggs	1.98	1.58	1.69	2.51	0.46	0.37	1.5	2.95	0	3.33	8.47
15	Fish larvae	0	5.17	2.16	0.34	0.12	1.22	0.29	0.41	0.3	0.09	0.08

Table 3.7: Abundance of Macrobenthos (No./m^2) in the study area

NO	Taxa	NKP1	NKP2	NKP3	NKP4	NKP5	NKP6	NKP7	NKP8	NKP9	NKP10	NKP-OFP
	Polycheata											
1	*Nephtyidae*sp.	50	200	0	200	400	700	500	600	150	800	100
2	*Orbinidae*sp.	50	0	0	50	0	50	0	100	200	50	50
3	*Spionidae*sp.	0	150	50	150	0	600	300	400	50	50	0
4	*Opheliidae*sp.	0	50	0	200	0	300	850	350	0	100	0
5	*Glyceridae*sp.	100	0	200	0	400	350	250	250	0	350	0
6	*Nereidae*sp.	0	50	0	100	50	0	0	50	0	50	150
7	*Pilardigae*sp.	0	0	0	50	50	0	0	50	0	0	0
8	*Aphroditidae*sp.	0	0	0	0	0	0	0	50	0	0	0
9	*Cossuridae*sp.	50	0	0	0	50	100	50	50	0	0	50
10	*Cirratulidae*sp.	100	0	100	50	0	200	350	550	0	100	100
11	*Terebellidae*sp.	0	0	50	0	0	0	0	0	0	0	0
12	*Syllidae*sp.	0	100	0	50	100	150	0	150	0	250	0
13	*Maldanidae*sp.	0	0	0	0	0	300	100	0	100	200	100
14	*Capitellidae*sp.	0	0	0	0	0	0	0	0	0	50	0
15	*Pisionidae*sp.	0	2200	0	400	800	0	0	0	0	700	400
16	*Eunicidae*sp.	150	50	0	0	0	0	450	250	0	0	0

Table 3.7: Abundance of Macrobenthos (No./m^2) in the study area *continued*

17	*Sabellidae*sp.	0	0	0	0	0	50	0	50	0	50	0
18	Unidentified polycheates	200	150	150	200	250	350	250	450	100	350	200
	Arthropoda											
19	Amphipoda sp.	0	0	100	200	0	100	0	150	0	300	0
20	Isopoda sp.	0	0	50	0	0	0	0	50	50	0	0
21	Cumacean sp.	0	0	0	50	0	0	50	50	0	0	0
22	Mollusca	0	0	0	0	0	0	50	0	50	0	150
23	Bivalvia	0	0	0	100	0	0	0	0	0	50	0
	Minor phyllum											
24	Sipunculus	100	50	100	200	150	200	100	100	100	50	100
25	Nematoda	450	400	200	400	650	950	1050	950	100	450	50
	Density no/m²	1250	3400	1000	2400	2900	4400	4350	4650	900	3950	1450
	Biomass g/m²	1.455	4.755	4.375	4.85	3.35	8.985	7.195	5.96	1.155	2.585	1.215

Table 3.8: Macrobenthic diversity index in the study area

Station	S	N	J'	H' (log)
NKP-1	9	1250	0.87	1.91
NKP-2	10	3400	0.58	1.33
NKP-3	9	1000	0.94	2.07
NKP-4	15	2400	0.91	2.47
NKP-5	10	2900	0.84	1.93
NKP-6	14	4400	0.88	2.33
NKP-7	13	4350	0.85	2.19
NKP-8	19	4650	0.85	2.52
NKP-9	9	900	0.95	2.09
NKP-10	17	3950	0.85	2.40
NKP-OFP	11	1450	0.9108	2.184

Number of species (S), number of specimens (N), Pielou'seveness (J') and Shannon index (H') of macrobenthos off Nakkapalli

Table 3.9: Meiofaunal abundance (No./10 cm^2) in the study area

	NKP1	NKP2	NKP3	NKP4	NKP5	NKP6	NKP7	NKP8	NKP9	NKP10	NKP-OFP
Nematoda	456	520	407	710	420	370	311	350	640	360	468
Harpacticoida	50	34	32	0	20	18	18	8	50	58	0
Turbellaria	85	28	160	160	100	46	36	22	60	40	60
Polychaeta	28	26	20	10	10	15	0	14	14	10	50
Ostracoda	13	10	0	20	20	7	10	6	9	0	10
Foraminifera	20	14	12	6	24	20	3	0	24	8	0
Tanaidacea	0	12	10	20	0	36	0	0	0	6	0
Nauplli	30	196	20	30	64	20	29	12	40	8	0
Tardigrada	15	0	7	30	14	12	10	0	22	10	38
Kinorhyncha	0	0	0	20	6	0	6	4	0	8	0
Total	697	840	668	1006	678	544	423	416	859	508	626

Chapter 4
TOXICOLOGICAL STUDIES

4.1. Introduction

Toxicity of the effluents can be evaluated by employing several tests. Bioassay is one of the important tests among them and it is used to test the sensitivity of the organisms on exposure to a toxicant. Bioassay is defined as the test in which a living tissue, organism or group of organisms are used as a reagent for determination of the potency of any physiologically active substance of unknown activity. In this experiment, a test species either a larva or adult is exposed to different concentrations of toxicant in a given time in order to know the nature and degree of response. During acute toxicity experiments, the tolerance response of the organism is evaluated by exposing it to the specified toxicant for a short period of time. In general, the level of tolerance of any organism to the toxicant is observed for a period of 96hrs in acute toxicity experiments. Static bioassay is widely used as a short-term response experiment for acute toxicity experiments and this is one of the best methods to provide the results very fast and accurately. In this experiment, the response of a toxicant to the organism is measured in terms of mortality or lethality. But as per APHA (2000), these experiments can be carried out in a static renewable media in which the medium is changed for every 24hrs with the respective concentrations of the toxicant. During renewal process, the excretory wastes and other mucous secretions of the organism in response to the toxicant, if any, can be eliminated. According to APHA (2000), this is a reliable method and yields good result. Therefore, it has become widely used to study the toxicity of industrial effluents.

4.2. Toxicity Tests

In the present investigation, Whole Effluent Toxicity (WET) methods of USEPA were employed to assess the potential toxicity of effluents using the post larvae of black tiger shrimp (*Penaeus mondon*) and fingerlings of grey mullet (*Mugil cephalus*) as test species. The results of these tests can be used for a variety of functions including resource consent monitoring and compliance, toxicity identification evaluations and evaluation of effluent treatment processes. WET tests were performed to determine the actual impacts of effluents on organisms residing in receiving waters where the effluents were discharged.

4.2.1 Tiger Shrimp Post Larvae (*Penaeus mondon*)

The shrimp species selected for bioassay experiments was Black tiger shrimp, *Penaeus monodon* (Fabricius). The taxonomic position of the test species is given below:

Phylum: Arthropoda
Class: Crustacea
Subclass: Malacostraca
Series: Eumalacostraca
Superorder:Eucarida
Order: Decapoda
Suborder: Natantia
Section: Penaeidea
Family: Penaeidae
Subfamily: Penaeinae
Genus: *Penaeus*
Species: *monodon*

The test organism selected for toxicity tests was coastal marine shrimp species, *Penaeus monodon* (Fabricius 1798) with a common name Black tiger shrimp (Fig. 4.1). The selected species abundantly occurs along the both east and west coasts of India inhabiting back waters, estuaries, coastal bays and shelf waters. Further, the

hatchery technology of this species has been standardized and the desired sizes of these larvae could be easily procurable from hatchery.

Fig. 4.1: Post larvae of Black tiger shrimp (*Penaeus monodon*)

Large number (~5000) of healthy post larval stages of tiger shrimp were procured from a commercial hatchery and transported to the Aquaculture Laboratory of CSIR-National Institute of Oceanography (CSIR-NIO) in oxygenated polythene bags. After their arrival at the Laboratory, post larvae were acclimatized by keeping them in large tanks (cap. 2000 litre) with continuous aeration for a minimum period of two weeks before being subjected to bioassay experiments.

During the acclimatization period, post larvae of tiger shrimp were fed with artificial pellet feed *ad libitum* twice a day. Basic data such as shrimp behaviour, feeding rate, etc were recorded. Before the start of bioassay experiments, the length and weight of the test animals were recorded and found to be having a mean length of 13±0.3 mm

and weight of 35±5 mg. Physico-chemical parameters of seawater in the acclimation tanks fell within the recommended optimum levels for rearing of tiger shrimp post larvae: water temperature, (30.3±0.5 ºC), salinity (30±1.5 ppt), dissolved oxygen (6.4±0.2 mg/l), pH (7.7±0.4), NO_2-N (<0.02 mg/l) and NH_3/NH_4 (0 mg/l).

Healthy and actively moving post larval stages of *P. monodon* (average length: 15±0.3 mm and weight of 39±4 mg) were selected for toxicity experiments. Batches of 20 post larval stages of shrimps of were randomly picked with a hand net and released into the test containers containing 2 litres of test solutions of different concentrations of suspended particulate phase (SPP) of water based drilling fluids.

4.2.1 Fingerlings of grey mullet (*Mugil cephalus*)

The finfish species selected for acute toxicity was the grey mullet (*Mugil cephalus*). The taxonomic position of the test species is given below:

Phylum: Chordata
Class :Teleostomi
Subclass:Actinopterygii
Order: Mugiliformes
Suborder: Mugiloidae
Family: Mugilidae
Genus: *Mugil*
Species: *cephalus*

The selected finfish species (*Mugil cephalus*) (Fig. 4.2) is a coastal species and often enter estuaries and rivers and usually occurs in schools over sand or mud. This species has worldwide and is cosmopolitan in almost all tropical and temperate coastal zones. In India, this species occurs in the estuaries, coastal and shelf waters along the east and west coasts of India. This species is known to occupy in more than one ecological niche. Furthermore, this species and related taxa support important fisheries, especially in developing countries.

Fig. 4.2: Grey Mullet (*Mugil cephalus*)

Fingerlings of grey mullet *(Mugil cephalus*) in the size (total length 25-32 mm, wet weight 300-450 mg) were collected from the brackish water ponds. Immediately after being caught, the larvae were transferred into 1000 L tanks fitted with aeration system. During laboratory conditions prior to experiment, post larvae of grey mullet were fed daily with freshly hatched nauplii (Instar-1) of Brine shrimp (*Artemia salina)*. Optimum concentrations of dissolved oxygen (>6 mg/l) in acclimation tank was maintained with continuous aeration (BOYU air-pump Model-u-9900). Batches of 20 fish post larvae were randomly picked with a hand net and released into the test containers containing 2 litres of test solutions of different concentrations.

4.2.3. Experimental Set-up

Seawater used as diluent and for exposure experiments was filtrated through a 1.0 μm mesh prior to analysis. All the experiments were conducted at room temperature of 28 °C, with a maximum day and night variation of 2 °C. No Feed was given to test animals 48 hrs prior to the experiments or during the experiments. Different concentrations of test solutions of effluent were chosen for following sets of experiments, under slow continuous aeration. Dissolved oxygen in the experimental and control tanks was always maintained >5 mg/l throughout the exposure study using artificial aeration. Each set of experiment was accompanied by a Control with

three replicate. Appropriate volumes of effluent concentration prepared as above were added to containers tanks containing post-larvae of tiger shrimp (*Penaeus monodon*) and fingerlings of grey mullet (*Mugil cephalus*).

The test containers were inspected at regular intervals for recording mortality at different exposure periods of 24 hrs, 48 hrs, 72 hrs and 96 hrs for calculating the LC_{50} values. The dead organisms were removed immediately from tanks in order to avoid any type of bacterial contamination. Records were also maintained for any abnormal behaviour of the test animals. At the end of each test, the organisms were transferred to a clean tank for observing their recovery. The average percent mortality recorded at different test solutions in triplicate test containers during the four exposure periods was determined. The median lethal concentration (LC_{50}) values in percentage of toxicant for post larvae of *Penaeus monodon* exposed to different concentrations of effluent were calculated based on the mortality rates.

In order to prepare different test solutions, clean seawater filtered through 1.0 μm mesh was used as dilution water. The physico-chemical characteristics of exposure seawater/diluent seawater are presented in **Table 4.1**

Table 4.1: **Physico-chemical characteristics of exposure/diluent seawater used for preparing test solutions.**

Parameter	Unit	Values
pH	**-**	**7.5±0.4**
Salinity	**ppt**	**30.0±0.3**
Dissolved oxygen	**mg/l**	**6.7±0.5**
Temperature	**°C**	**28.2±1.2**
Nitrite-Nitrogen (NO_2-N)	**mg/l**	**<0.03**
Ammonia as NH_3/NH_4	**mg/l**	**NIL**
Nitrate-nitrogen (NO_3-N)	**mg/l**	**2.5±0.4**
BOD	**mg/l**	**1.4**

Water Quality Monitoring during WET Test

The physico-chemical parameters of the effluents observed include pH, temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD). The temperature was measured with mercury-in-glass thermometer. The DO of the effluent was determined by the Winkler's method, while the pH was determined using calibrated pH meter. The data on measured physico-chemical parameters is presented in **Table 4.2**

Table 4.2: Data on measured physico-chemical parameters of treated effluents

Effluent Nomenclature	Temp. (°C)	DO (mg/l)	BOD (mg/l)	pH
AOL	28.6	5.6	31.2	7.7
RPCL	28.2	6.5	19.6	7.3
ML	28.7	6.8	44.2	7.4
BIACL	28.2	6.3	16.9	7.8
DFC	28.3	6.4	18.4	7.4
APL	28.3	6.9	52.5	7.8
DLL	28.6	6.8	29.2	8.4
HDL	28.4	7.1	12.8	8.3
LP	28.1	6.2	9.5	8.5

Test conditions and test acceptable criteria for whole effluent toxicity of treated effluents with post larvae of tiger shrimp (*Penaeus monodon*) and grey mullet (*Mugil cephalus*) is presented in **Table 4.3**

Table 4.3: Summary of conditions and acceptability criteria for WET acute Toxicity Test with post larvae of tiger shrimp and grey mullet as test species.

Type	Comment
Test condition	**Static non-renewal**
Test duration	**96 hrs**
Temperature	**>28 °C**
Photoperiod	**12 hrs light: 12 hrs dark**
Test chamber size	**4 Litres**
Age of test organisms	**30 Day Post Larvae**
No. organisms per test chamber	**20 animals**
No. replicate chambers per Conc.	**Three**
Feeding	**None**
Test solution aeration	**Yes, >4 mg l^{-1}**
Dilution water	**30 ± 2‰ salinity**
Test concentrations	**effluent conc. and a control**
Dilution series	**Effluents: ±0.5 dilution series**
Endpoint	**Effluents: Mortality**
Sample volume	**Nil**
Test acceptability criterion	**90% survival in 100% effluent**

Mortality of test organisms for effluent samples over different exposure periods are presented in the Results Section. The mortality values of effluent water samples for different exposure periods (24 hrs, 48 hrs, 72 hrs and 96 hrs) were calculated following the method of log-probit transformation for time and dose-mortality curves suggested by Finney's method (1971) using LDP line software (http://embakr.tripod.com/ldpline).

4.3. Results

4.3.1 Acute Toxicity of treated effluent with WET test

Acute toxicity of treated effluents with whole effluent toxicity test expressed in terms of median lethal concentrations (LC_{50}) was evaluated by subjecting the acclimatized post larvae of shrimp (*P. monodon*) and grey mullet (*M. cephalus*) exposed to four exposure periods (24 hrs; 48 hrs; 72 hrs and 96 hrs) with seven different concentrations (% v/v) of effluent test solutions. Experiments were conducted under static conditions and all experimental tanks had a triplicate and each experimental set included a Control (0%). The average percent mortality recoded at different test solutions in triplicate test containers during the four exposure periods was determined.

Data on average mortality of test animals (in %) recorded in different test concentrations of treated effluent from Hetero Drugs Ltd (HDL) over four exposure periods is presented in **Table 4.4**. The median lethal concentrations (LC_{50}) of treated effluent from HDL at different exposure periods are shown in **Table 4.5.** Experimental setup used for 96 hr LC_{50} of HDL effluent with post larvae of tiger shrimp (*P. monodon)* and with fingerlings of grey mullet (*M. cephalus*) is shown in Fig. 4.3 and Fig. 4.4, respectively. During the 96 hrs exposure period, no mortality was observed in control treatment. During the 96 hrs experiment, >60% mortalities in post larvae of shrimp and fish were recorded at test concentrations of 100% effluent.

Table 4.4: Cumulative mortality (%) in post larvae of tiger shrimp (*Penaeus monodon*) and grey mullet (*Mugil cephalus*) recorded at different concentrations of treated effluent from M/s. Hetero Drugs Ltd (HDL) during four exposure periods.

Test Effluent (%) (HDL)	*Exposure periods*			
	24 hrs	48 hrs	72 hrs	96 hrs
Mortality in experimental shrimp post larvae (%)				
Control (0%)	0	0	0	0
3.12	0	0	10	15
6.25	0	5	20	25
12.5%	10	15	30	30
25%	15	20	40	45
50%	20	35	50	50
80%	20	40	50	55
100%	30	45	55	60
Mortality in experimental grey mullet fingerlings (%)				
Control (0%)	0	0	0	0
3.12	0	5	10	15
6.25	5	15	20	25
12.5%	10	20	25	35
25%	15	25	35	45
50%	20	30	45	50
80%	25	40	55	60
100%	30	45	60	65

Table 4.5: The median lethal concentrations (LC_{50}) of treated effluent from M/s. Hetero Drugs Ltd at different exposure periods obtained from Figures 4.5 and 4.6 for two test species have been tabulated below:

Exposure period (hrs)	Median Lethal Concentrations (LC_{50} Values)	
	Post larvae of tiger shrimp % (v/v)	Post larvae of grey mullet % (v/v)
24	744.38	445.29
48	123.25	158.65
72	61.83	59.96
96	48.57	39.55

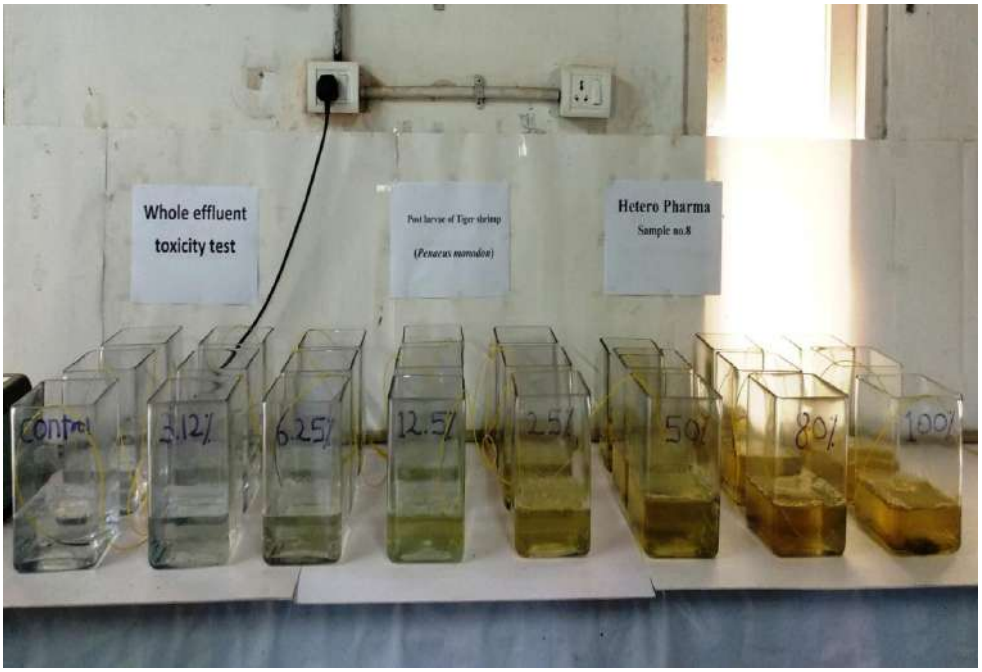


Fig. 4.3: Experimental setup used for 96 hr LC_{50} of Hetero Pharma effluent with post larvae of tiger shrimp (*Penaeus monodon)*

Fig. 4.4: Experimental setup used for 96 hr LC_{50} of Hetero Pharma effluent with fingerlings of mullet (*Mugil cphalus*)

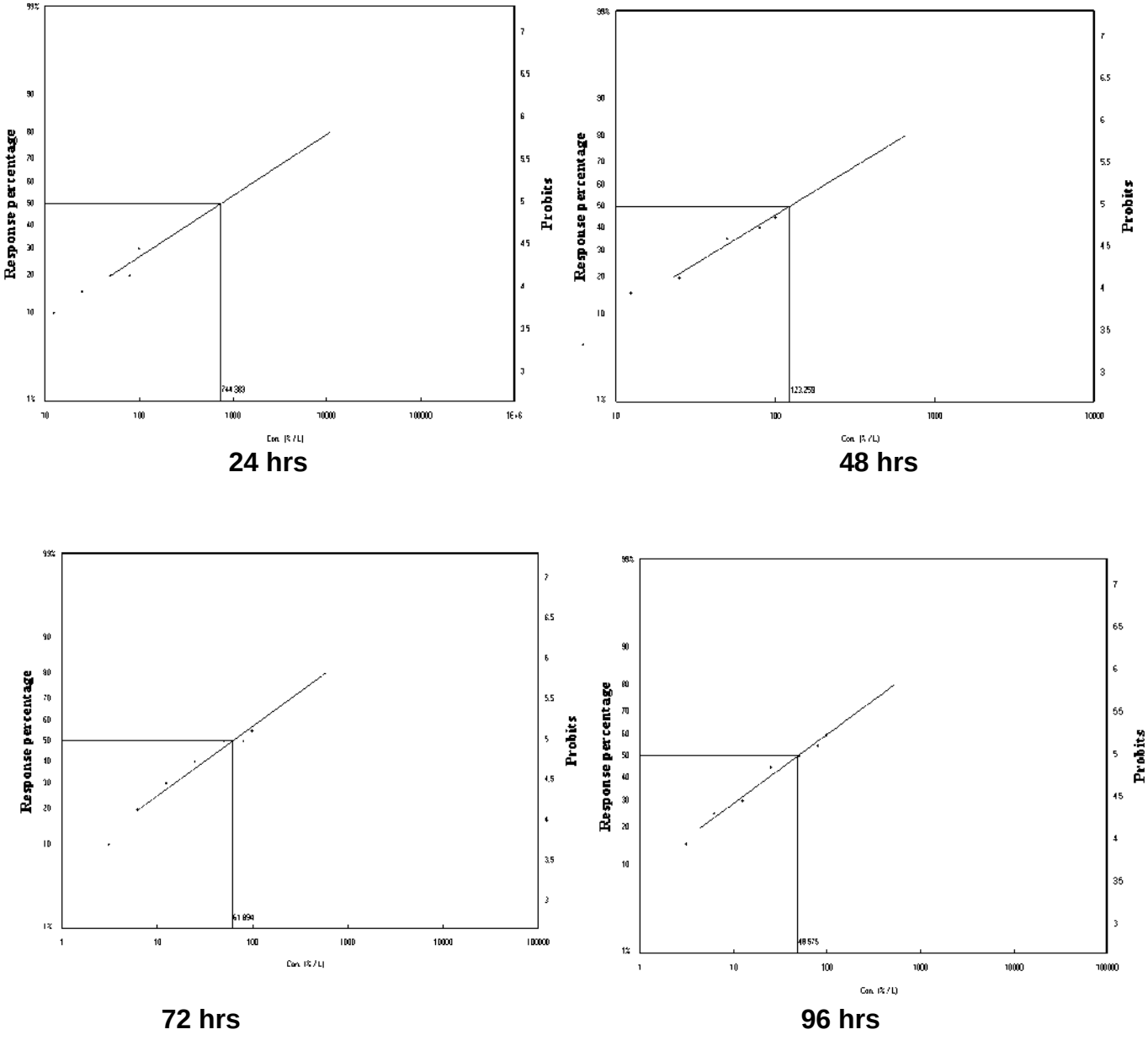
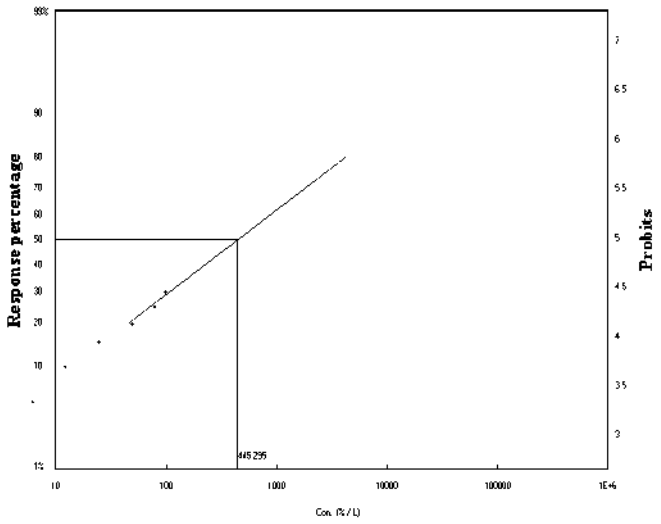
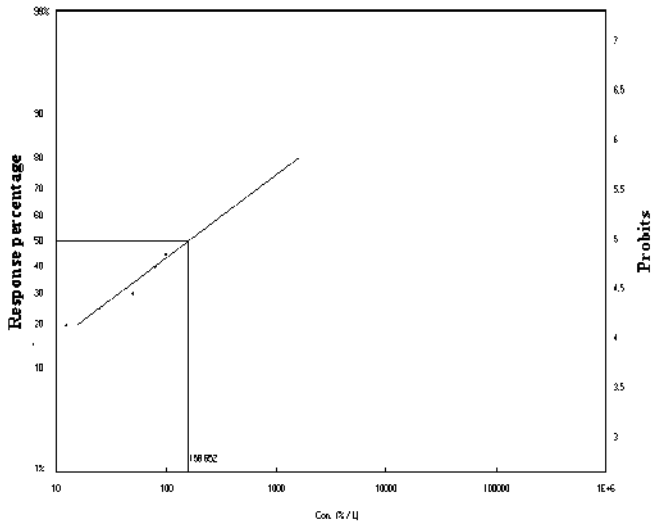


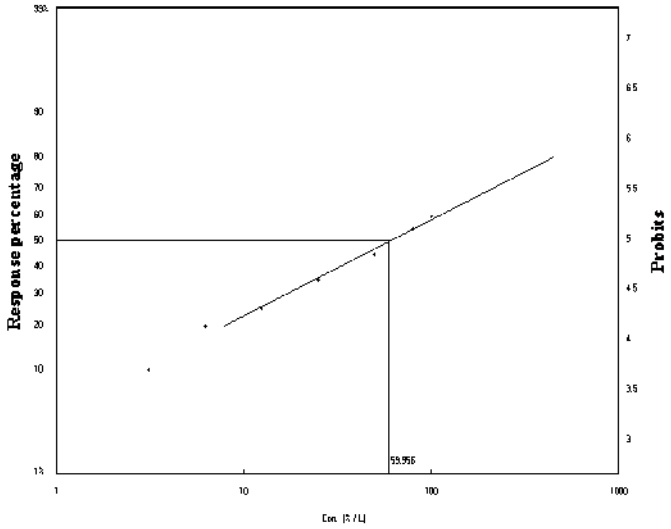
Figure 4.5: Median lethal concentrations (LC_{50} values) of treated effluent from Hetero Drugs Ltd (HDL) to post larvae of tiger shrimp (*Penaeus monodon*) at different exposure periods.



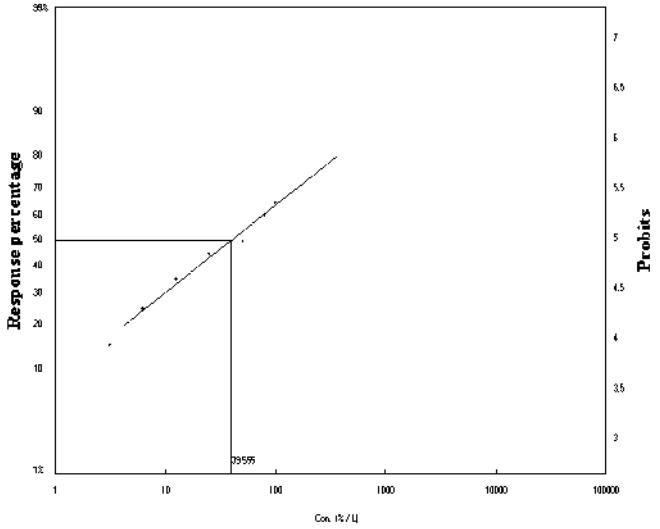
24 hrs



48 hrs



72 hrs



96 hrs

Figure 4.6: Median lethal concentrations (LC_{50} values) of treated effluent from Hetero Drugs Ltd (HDL) to fingerlings of grey mullet (*Mugil cephalus*) at different exposure periods.

Median lethal concentrations (96 hrs LC_{50}) obtained for the treated effluent with post larvae of tiger shrimp and grey mullet are presented in **Table 4.6.**

Table 4.6: The determined Median lethal concentrations (96 hrs LC_{50} values) obtainedfor post larvae of shrimp and grey mullet for treated effluent from M/s Hetero Drugs Limited.

Effluent Nomenclature	96 hrs LC_{50} values (%v/v)		
	Shrimp Post larvae	Grey mullet fingerlings	Mean
HDL	48.57	39.55	44.06

Furthermore, an assessment of acute ecotoxicity of different treated effluents was made in terms of Acute Toxicity Units (TUa). Recently, various industrial effluents that require discharge permits are assessed through the 'TUa' ($TUa=100/LC_{50}$ %v/v)- it is a specified criterion used for discharge monitoring permits routinely used by US-EPA. For each test performed the toxicity unit was calculated as 100% (full strength effluent expressed as percentage) divided by the LC_{50} values. Acute toxicity units (TUa) obtained for treated effluents from M/s Hetero Drugs Limited is 2.06 for Tiger Shrimp Post larvae and 2.53 for Grey mullet fingerlings.

The following criteria (Table 4.7) used by Pool et al (2009) was used to assess the level of ecotoxicity of treated effluents for post larvae of shrimp and fish (Table 25).

Table 4.7: Acute Toxicity Grading of treated effluents based on Toxicity Units (TUa)

Toxicity Unit (TUa)	Category
<1.0	**Limited/or not acutely toxic**
1 - 2	**Negligibly acute toxic**
2- 10	**Mildly acute toxic**
10 – 100	**Acutely toxic**
>100	**Highly acutely toxic**

Based on the above criterion, the treated effluents from different from M/s Hetero Drugs Limited is graded as **MILDLY ACUTE TOXIC**.

Chapter 5
SUMMARY AND CONCLUSION

1. The quality of waters around the marine outfall point during the observational period is similar to that of a typical coastal environment. The results of the present study are comparable to those obtained in earlier monitoring studies conducted in 2012 and 2014 in the same region. Relatively high nutrients and less dissolved oxygen in the bottom waters than that of the surface is due to the consumption of nutrients by phytoplankton in the surface and release of nutrients and oxygen during heterotrophic decomposition of organic matter in the bottom waters.

2. The concentration ranges of all chemical constituents in the vicinity of marine outfall are well within the ambient levels of a healthy coastal environment and would not pose a threat to marine biota.

3. The normal range of microbial flora such as total viable bacterial counts (TVC), total *coliform* and *E. Coli* like organisms (ECLO) in the surface waters (5.6 - 13.6x10^3, 0.3-0.8x10^3 and 1.5-3.7x10^3 CFU/ml respectively) and bottom waters (3.2-33.0x10^3, 0.2-1.2x10^3 and 0.7-7.4x10^3 CFU/ml respectively) suggest that the marine environment the vicinity of the outfall location is healthy and no significant microbial contamination is evident in the region.

4. Total number of phytoplankton genera recorded in the surface water varied 12-19 in surface and 15-22 in the bottom waters. The majority of the phytoplankton taxa is diatoms. The important genera of phytoplankton in the region are *Cheatoceros* , *Nitzschia sp., Pseudo-nitzschia* , *Rhizosolenia* sp., *Skeletonema , Navicula Thalassionema Thalassiosira Thalassiothrix Coscinodisus and Guinarida*.

5. A total of 15 different taxa including larvae were recorded for zooplankton. The numerical counts of different taxa recorded in the study area varied between 500 and 3239 Ind/m^3 while the biomass was in the range of 0.03 - 0.41 ml/m^3. The most dominant taxa recorded was copepod, with a contribution of 75.8 to 94.3% to the total abundance. The overall picture of the zooplankton in the study area suggests that the composition and biomass were moderately high and attributed to inter annual variations.

6. The population density of macrofauna ranged from 900 to 4650 individuals/m^2. The total wet weight of biomass was in the range of 1.22–8.99 g/m^2. Polychaetes are the major contributor to the wet weight of biomass.

7. Total count of meiofauna was in the range of 416-1006 No/10cm^2 with a mean value of 661$\pm$186/10cm^2. Nematodes were the most dominant group with numerical density of 311-710/10cm^2 and percent composition of >80% at all stations

8. A comparison of biological data of the present study with the results of previous monitorings conducted in 2012 and 2014 revealed that there is no significant change in the biological characteristics of the region. Hence, it is concluded that the effluent discharge from M/s Hetero Drugs Limited has no significant adverse impact on ecology of the marine environment.

9. The toxicological study carried out on the effluent from Hetero Drugs Limited suggests that the effluent is MILDLY ACUTE TOXIC with a TUa values of >2. In the exposure of 100% effluent, the mortality was higher than 60% after 96 hours. Hence, further treatment of effluent is required before discharging in to the sea,

10. Bioassay tests and post project monitoring should be continued with a periodicity of once in two years to know the cumulative effects on the marine environment because of industrial development in the marine sector, ecological sensitiveness of the study area and requirement of improvement in the treatment of effluent before discharge into the sea.

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SV ENVIRO LABS & CONSULTANTS

(Environmental Engineers & Consultants in Pollution Control)

Corporate Office & Laboratory : Enviro House, B-1, Block-B, IDA, Autonagar, Visakhapatnam-530012
www.svenvirolabs.com, Ph:0891-2755528, Cell: +91 9440338628
info@svenvirolabs.com, svenviro_labs@yahoo.co.in

Branch Office : 2-53, Mahipala Street, Yanam - 533464.

Recognized by Govt.of India-MoEF & CC, New Delhi, Accredited by : NABL & NABET

Ref: SVELC/HISL/21-12/01 Date: 17-12-2021

NAME AND ADDRESS : **M/s. HETERO INFRASTRUCTURE SEZ LIMITED,**
N.Narasapuram Village, Nakkapally Mandal,
Visakhapatnam (Dt).

SAMPLE PARTICULARS : **WATER**

SOURCE OF COLLECTION :
1. BOREWELL – 1 (Near ETP)
2. BOREWELL – 2 (Near Honour Labs)
3. BOREWELL – 3 (Near Labour Shed)
4. BOREWELL – 4 (Near HLL-3)

DATE OF COLLECTION : **14-12-2021**

TEST REPORT

S.No	Parameter	Unit	Results			
			1	2	3	4
1.	pH	-	8.53	7.33	7.79	7.93
2.	Total Dissolved Solids	mg/l	7560	30250	13100	13605
3.	Total Alkalinity as $CaCO_3$	mg/l	476	356	415	536
4.	Total Hardness as $CaCO_3$	mg/l	960	9038	1640	1760
5.	Calcium as Ca	mg/l	48.1	577	144	192
6.	Magnesium as Mg	mg/l	204	1846	311	312
7.	Chlorides as Cl^-	mg/l	3242	13962	5226	5681
8.	Copper as Cu	mg/l	<0.01	<0.01	<0.01	<0.01
9.	Manganese as Mn	mg/l	0.26	2.90	0.56	0.06
10.	Zinc as Zn	mg/l	0.40	0.50	0.09	0.19
11.	Aluminum as Al	mg/l	0.17	0.62	0.04	0.18
12.	Boron as B	mg/l	1.80	0.86	1.30	1.10
13.	Barium as Ba	mg/l	0.16	0.08	0.05	0.10
14.	Selenium as Se	mg/l	0.02	0.06	0.04	0.04
15.	Silver as Ag	mg/l	<0.01	<0.01	<0.01	<0.01
16.	Cadmium as Cd	mg/l	<0.01	<0.01	<0.01	<0.01
17.	Cyanide as CN	mg/l	<0.01	<0.01	<0.01	<0.01
18.	Lead as Pb	mg/l	<0.01	<0.01	<0.01	<0.01
19.	Mercury as Hg	mg/l	<0.01	<0.01	<0.01	<0.01
20.	Nickel as Ni	mg/l	0.04	<0.01	<0.01	<0.01
21.	Total Arsenic as As	mg/l	0.05	0.13	0.06	0.03
22.	Total Chromium as Cr	mg/l	<0.01	<0.01	<0.01	<0.01
23.	Iron as Fe	mg/l	0.21	0.12	0.10	0.08

Note: All the above parameters are tested as per APHA methods, 23rd Edition, 2017

CHECKED BY

SV ENVIRO LABS & CONSULTANTS

CIN : U45200TG2006PLC049668

HETERO INFRASTRUCTURE SEZ LTD.

Ch. Lakshmipuram (Vill.), N. Narasapuram (Vill.), Rajayyapeta (Vill.), Nakkapally (Mandal)
VISAKHAPATNAM (Dist.) - 531 081. A.P., India. Tel : 08931- 227307, Fax : 08931- 227200
E-mail : contact@heterodrugs.com. URL : http//www.heterodrugs.com.

29th September 2021

Letter No: HIS/EHS/APPCB/2021-22/07

The Environmental Engineer
Regional Office
Andhra Pradesh Pollution Control Board
Visakhapatnam

Dear Sir,

Sub: Submission of Environmental statement in Form-V for the year ending 31st March 2021-Regarding.

Reference:

1. CFO of M/s Hetero Labs Ltd, Unit-IX vide Order NO:
   APPCB/VSP\VSP/219/CFO/HO/2017-, Date: 11/12/2017
2. CFE of M/s Hetero Labs Ltd, Unit –IX Vide Order No:
   219/PCB/CFE/RO-VSP/HO/2010-2355, Date: 13/11/2018

With reference to the above, we are herewith submitting Environmental Statement in Form-V for the financial ending 31st March 2021 for your information and perusal.

Kindly acknowledge the receipt.

Thanking You,

Yours Faithfully
For Hetero Infrastructure SEZ Ltd

29/9/21

S. Kullayi Reddy

Sr. General Manager- EHS

Enclosures: As above

PROFILE

M/s. HETERO INFRASTRUCTURE SEZ Ltd, obtained EC & consent for establishment for setting up of 17 manufacturing facilities for producing Bulk Drug intermediates & APIs and also got Consent for operation for the same SEZ. Out of 17 permitted units, Hetero constructed following 03 units in Hetero Infrastructure SEZ Ltd:

- Hetero Drugs Ltd, Unit-IX (Plot No:1)
- Hetero Labs Ltd, Unit-IX (Plot No: 2 & 3)
- Honour Lab Ltd, Unit-III (Plot No:4)

All above mentioned units are producing Bulk Drugs & API and all these products are being manufactured on Regular basis. Manufacturing of the products is being undertaken as per the consent conditions.

Hetero Infrastructure is providing services like Water, Steam, Effluent Treatment Plant, Sewage Treatment plant, Vermi Compost plant etc to all the above mentioned units.

Apart from above mentioned units, the other unit Hetero Labs Ltd, Unit-III is making use of these facilities of Hetero Infrastructure SEZ Ltd as per the CFE & CFO.

SALIENT FEATURES OF
M/s. HETERO INFRASTRUCTURE SEZ LIMITED

Total Site Area	340 Acres
Built up Area	180 Acres
Area of Green Belt Developed	90 Acres
Area available for Green Belt Development	50 Acres
Year of Establishment	2010
Year of Commissioning	2011
Capital Cost	120 Crores
Type of plant	Facilitator for Bulk Drug Manufacturing units
Water Consumption as on date	546.15 KLD
Investment on Pollution Control	
• Capital Investment	100 Crore
• Recurring O & M	200 Lakhs/annum
Employment	300

MINISTRY OF ENVIRONMENT AND FORESTS NOTIFICATION
New Delhi, the 22nd April 1993
(PART II, SECTION 3, SUB-SECTION (1)

"FORM - V"
ENVIRONMENTAL STATEMENT FOR
THE FINANCIAL YEAR ENDING THE 31ST MARCH 2018.

PART - A

Name and address of the owner/ Occupier of the industry, operation Or process		**Dr. C. Mohan Reddy, Director** 7-2-A2, Hetero Corporate, Industrial Estate Sanathnagar Hyderabad -5000082..
Registered Office Address	:	**M/s. Hetero Infrastructure SEZ Ltd,** 7-2-A2, Hetero Corporate Industrial Estate Sanathnagar Hyderabad -5000082 Tel:3704923/24/25
Works address	:	**M/s. Hetero Infrastructure SEZ Ltd,** N.Narsapuram (V), Nakkapally (Md), Visakhapatnam Dist.
Industry Category	:	Red.
Production Capacity	:	NA (Only Services)
Month and Year of Establishment	:	2010.
Date of Last Environmental Statement Submitted	:	September 2020

PART-B

Water and Raw Material Consumption

(i) Water consumption: m^3/d

S.No	Water Consumption	Quantity (KL/day) Including power plant (As per CFO)	Quantity (KL/day) Including power plant
1.	Process & Washing	837	NA
2.	Cooling tower Make up	250	NA
3.	Boiler Feed	330	310
4.	Domestic	120	10
5.	Raw water RO make up	107	50
Total		**1644**	**370***

*indicates water consumption in Boilers only.

PART-C

Pollution discharged to environment/unit of output
(Parameter as specified in the consent issued)

	Quality ofPollutants discharged (mass/day)	Concentrations of Pollutants discharges (Mass/volume)	Percentage of variation from prescribed standards with reasons.
1.Ambient Air Quality	Analysis Report Enclosed as **Annexure-I**		Within the limits
2.Stack Emissions			
3.Noise levels			
4.Effluent			

PART-D

HAZARDOUS WASTES

(As specified under 1[Hazardous Wastes (Management, Handling and Transboundary movement) Rules, 2008)]

Hazardous Wastes	Total Quantity (Kg.)	
	During the previous financial Year **(2019-20)**	During the current financial Year **(2020-21)**
Forced Evaporation Salts	1807.9 Tons	2205.4 Tons
ETP Sludge	93 Tons	53.21 Tons
Incinerator Ash	NIL	6.12

PART-E

SOLID WASTE

Solid waste	Total Quantity	
	During the previous financial year **(2019-20)**	During the current financial year **(2020-21)**
Boiler ash	----	7560 Tons

PART-F

CHARACTERISTICS INTERMS OF COMPOSITION AND QUANTUM OF HAZARDOUS AS WELL AS SOLID WASTES AND THE DISPOSAL PRACTICES ADOPTED BY THEM

Fly Ash from Boiler	: To Brick Manufacturers
Spent Carbon from Process	: To TSDF , Parawada / Cement Industries
Forced Evaporation Salts	: To TSDF , Parawada
Organic Residue	: To TSDF , Parawada and Cement Industries

PART-G

Impact of the pollution abatement measures taken on conservation of natural resources and on the cost of production.

The industry has adopted following measures for the conservation of natural resources:

- Sea water Desalination Plant for meeting the water requirement of the Industry.
- Sewage Treatment Plant for reuse of Domestic wastewater for gardening purposes.
- Usage of vermicomposting for Green belt and grounding purpose as a replacement for chemical fertilizers.
- Green belt Development for abatement of pollution

The Industry adopted all possible pollution control measures (Common Facility located at M/s Hetero Infrastructure SEZ Ltd) which includes Equipments for Conservation of energy, Effluent Treatment Plants (Stripper, MEE, ATFD Bio-tower & Dual stage aerobic Treatment plant based on ASP), Sewage Treatment plants, Equipments for controlling fugitive emissions (Scrubbers, Condensers) for the abatement of pollution. To avoid any chances of ground water/ Soil contamination, the industry has constructed all above Ground tanks for ETP, STP etc and installed above ground tanks for the collection of effluents at production blocks of various units.

Further the industry has installed 03 nos of Continuous Ambient Air Quality Monitoring (CAAQM) stations for monitoring the quality of the air, Online effluent monitoring system (OEMS) for various parameters to check the quality of treated effluents being disposed into Sea, Portable & online VOC meters for measuring organic vapours concentration in and around factory area.

PART-H

Additional measures/investment proposal for environmental protection including abatement of pollution, prevention of pollution.

The industry has already invested around Rs. 100.00 Crores towards installation of pollution control devices (In Hetero Infrastructure SEZ Ltd) and for development of green belt in and around the industry. Green belt consists of various plants like Ganuga, Neem, Almond, Silver oak, Plintoform, Casurina, Eucalyptus etc.
All installed Pollution control equipments are periodically evaluated and necessary modifications/replacements are being made from time to time for improvement in their performances.

The industry is proposed to invest Rs. 60.00 Crores during 2020-21 & 2021-22 for the installation of new 1 MLD Effluent Treatment Plant.

PART-I

Any other particulars for improving the quality of the environment.

- Increasing the greenbelt area by planting more plants, lawns, bushes etc.
- Industry is maintaining good housekeeping, mitigating fugitive emissions by way of installing hoods & scrubbers for equalization tanks, reducing spills of effluents by taking all possible measures.
- Recovering of solvents from the strippers of CETP thereby reducing the organic vapours entry into the atmosphere.
- Rainwater harvesting by collecting complete run off of the factory in an open pond for recharging of ground water as well as for reuse.

- Captive power generation of 6.1 MW in connection to the existing 45 TPH Boiler.
- Monitoring of existing systems and upgradation as and when required.
- Proposing to construction Bio manure pits for converting the food waste into organic manure.
- Part of treated effluent is being used as cooling tower makeup water in ETP area.
- Reusing steam condensate from SRS plants, ETP etc thereby reducing the freshwater consumption.

CONCLUSION

Hetero Infrastructure SEZ limited is taking all possible measures for the abatement of pollution and certain steps are in consideration for work improvement and cost reduction. The following are the pollution abatement measures taken by the industry:

1. Taking all steps required to assure low emission levels, without any prejudice to the quantum of production.
2. Utilization of domestic wastewater discharges for development of greenery after treating in Sewage Treatment Plants.
3. Using part of treated wastewater as cooling tower makeup in ETP.
4. Giving due importance to the greenery and ultimately taken care in abating the pollution.
5. Rainwater harvesting by way of collecting rainwater in a pond created by the industry
6. Online equipment (CAAQMS, CEMS and VOC) for monitoring the pollution levels in and around factory premises.
7. Operating Effluent Treatment Plant (Common) for bringing the pollution levels well within the norms of the Board.
8. Regular monitoring of air, water, effluent, and Ground water by third party once in a month to keep watch on the pollution levels.

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