

SIGNIFICANCE OF OCEANOGRAPHIC FIELD INVESTIGATIONS FOR SITING COASTAL THERMAL AND NUCLEAR POWER PLANTS

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1. INTRODUCTION

Today, the large coastal hydraulic projects are being executed in many parts of the world for shore protection purposes, development of harbours, coastal power plants, laying pipelines, construction of marine outfall systems etc. These projects are often located in estuaries or coastal waters where the ecology is characterised by high biological productivity and remarkable diversity of seascapes. These projects in this fragile zone can profoundly influence the environment and should therefore be developed with due regard to the ecosystems concerned. In India, five power plants are along its coast line and their numbers are on the increase. These plants draw large quantities of coolant water from the sea and discharge the heated water back into the coastal waters. The study of the effects of hot water discharges has therefore raised strong environmental concern. The study and monitoring/field investigations to quantify the mixing and diffusion processes of heated effluents in

the waste heat disposal has priority for protecting the ecosystem locally. These field observations and monitoring programmes provide the baseline data for the planning, engineering and operation of any coastal power plant. This paper covers some aspects of the practical problems which a surveyor faces in carrying out field observations. Basically, we can divide the interaction studies into three steps:

- (1) Quantification of those characteristics of the facility and the environment important in defining the interaction.
- (2) Setting the equilibrium points of the interaction through definition of the protection and prevention measures.
- (3) Control and optimisation through engineered features supported by monitoring programmes.

Such marine environment studies involve the theoretical determination of the residual con-

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centrations for different combinations of the discharge points and taking into account the current fields in the dispersion and diffusion pattern of the effluents in the area of interest, prior to the implementation of an outfall project. A discharge point can be considered acceptable if the pollutant outflow concentrations are consistent with the water quality standards applicable in the areas requiring protection. The main object of a sea outfall is to discharge effluents at an adequate distance from populated coastal areas, the outfall being located at a point at which local hydrodynamic effects will assist the dispersal of the effluent. In case of a power plant where once-through cooling system is adopted it is necessary to maximise the dispersion of the discharged hot water for minimising hot water recirculation back into the station intake for maintaining the station efficiency.

The offshore placement of the intake and discharge structures has also to be decided on the basis of minimal environmental impact as judged from the information available/collected such as areas of fishing activity estimated location of native and migratory biota, geology, spatial relationships between intake and discharge with themselves, the net drift of current, prevailing winds, etc. The dissolved oxygen (DO) concentration in a water body is also a particularly important parameter to evaluate in this regard. It is therefore advisable

to finalise the location of outfall after a full consideration of all able factors including the marine one. In other words, the outfall location should depend on the results of the marine environment study and not the reverse.

As estuaries provide a source of cooling water, a large number of power plants all over the world are situated and planned to be constructed on their banks. Estuarine organisms are often exposed to a variety of natural stresses including salinity variations, low DO due to high levels of productivity, turbidity caused by the stirring up of bottom sediments and the high plankton concentrations and sometimes to large temperature variations due to shallowness of water and restricted circulation. Estuaries also serve as an important nursery/breeding ground for a variety of aquatic species. Considering the magnitude of natural stress on estuarine organisms, any additional stress from thermal pollution is therefore to be minimised if not avoided. Hence estuaries are just about the last place where one would want to locate a power plant from environmental stress considerations.

2. FIELD OBSERVATIONS - PLANNING

In the waste heat dissipation studies, the marine medium is modelled as comprising of a series of homogeneous horizontal fluid layers. These are assumed to be vertically independent owing to the variation in their densities. Investigations and measurements should therefore be carried out

to depths at which a thermocline may be expected.

The measurements should extend over a sufficient length of time for the observations to cover all predominant wind directions and speeds as well as of extreme tides and other conditions if necessary during which sudden major thermocline fluctuations, internal waves and other major accidental phenomena, are more likely to occur.

The oceanographic effects are considerably influenced by the meteorological conditions. Therefore, the data collection must be spread over at least one calendar year to cover all significant weather conditions. Factors such as current velocities, characteristic bacterial disappearance, topography etc. which show spatial variations should be studied to cover the region of interest over the sea.

Planning, design and construction of marine outfall systems for effluent discharges have been well documented elsewhere (Grace, 1978, Quentin and De Reveille, 1986, etc.). Here we will look into some of the field problems and innovations required for carrying out field observations for a proposed thermal or nuclear power plant.

3. VESSEL, EQUIPMENT, FIELD LABORATORY AND THE TEAM

The boat used for coastal oceanographic survey work must be stable and have enough deck place. It should be equipped with a

winch, echosounder and mariner's compass. The operating time schedule of the boat should be prepared in advance after making due allowance for the difficulties associated with work at sea and the time lost in boat manoeuvres, time required to reach the desired location etc.

All the equipments should be carefully checked and calibrated before and after the measurements. The instruments which are deployed in the sea must be washed thoroughly with freshwater to remove salt deposits etc. Never open and service an electronic or other equipment at sea in the boat. The saline water spray can damage the equipment very quickly.

The field laboratory for storing and servicing equipment should be set up with enough fresh water and power supply and it should be located preferably near the landing place of the boat. Frequent handling and transporting of delicate equipment by road can do a lot of damage to them.

The survey team must be fit to work even under rough sea conditions and should be experienced/trained on the use, service and maintenance of all instruments used in the investigations. To promote greater team spirit, they must be made aware of the purpose of the survey and when and where and for what duration the data is to be collected. As the data collection process on a small boat in the coastal waters is always a tedious job, it could affect the members of the team adversely if continued for a long

time. This could be obviated by instituting a rotation or shift working among the members of the survey team.

4. POSITION FIXING

As most of the task is being carried out from a small boat and the area covered is extensive, ascertaining its position in the sea correctly, is a very important factor. Thus, information on the depth of water needs to be coupled with vocational particulars for a precise description of the observation station. During earlier days even now, position fixing using a sextant is most common. But when the boat is subjected to tossing by the waves, using a sextant is a difficult task even for experienced surveyors and the vocational accuracy of the boat will be in doubt. Moreover, the visibility should be very high to view the landmarks clearly for accuracy, which may not be the case always. Hence, nowadays, electronic position fixing systems (e.g. Miniranger) are deployed which give the instantaneous position of the boat very accurately. The time intervals between successive boat positions could be reduced so that even tracking peripheries of dye patches becomes easy and more valuable data could be collected during dye dispersion studies. In addition, the tracks or points can also be plotted simultaneously on chart papers.

Reoccupying a position fixed earlier is a very tedious and time consuming task using a sextant. Whereas using electronic

position fixing systems, this becomes easy and for these reasons, instruments like Miniranger become necessary for position fixing purposes during a coastal oceanographic survey.

5. SOME PRACTICAL PROBLEMS DURING DATA COLLECTION

Compared to deeper waters, in the coastal waters, the degree of biofouling of instruments deployed is very high. The recording current meters which are moored at different depths 12 to 15 days in the coastal waters are found to be covered by marine organisms and jam the moving parts like rotor in these current meters thereby rendering the data collected beyond 15 days to significant error. One solution to the problem is to retrieve the current meter every 12 to 15 days, retrieve the data, clean the instrument thoroughly, moor it again or replace it by another one. Temperature and conductivity sensors could also possibly get fouled. This particular problem cannot be successfully eradicated if we intend to have a long-term mooring.

The current measurements using other equipment like Acoustic Doppler Current Profiler should also follow the same practice. Even though it does not have any moving parts for measuring current speed, its transducer faces may get fouled (by barnacles etc.) even after taking precautionary measures (like smearing anti-fouling grease on transducers). Also it has been observed that transducer faces are getting

covered with sediment deposits during a long term mooring which could also give rise to deviation from the actual values.

The survey team often face problems in safeguarding the underwater moorings from boat traffic, fishing activities and theft in coastal waters. Surface marker floats are frequently lost either through accidents or theft resulting in the total loss of equipment along with valuable data. Once the marker floats are removed it is quite difficult to trace these moorings. To overcome this problem, there must be a round-the-clock watchkeeping near the moorings and proper indication warnings not to venture near the area of survey should be given to the local fishermen and other navigators through public media. National Institute of Oceanography (NIO), Goa is in the process of developing a device to trace the moorings if the surface floats are lost. This Mooring Monitoring Unit (MMU) could be easily attached to the mooring line underwater, and the acoustic signals produced by it could be received by a deck unit through hydrophone receiver. This fixture would also be helpful in tracing underwater moorings if the acoustic releases failed to work. So, as a precautionary measure it is advised to have a MMU on the mooring line. The current observations through insitu recording current meters are restricted because of their mooring depth limitations. The direct reading current meters (e.g. DRCM of NIO) can provide current profiles but again its

duration of operation is limited and at times, when the sea is rough, data collection could be difficult. To avoid these constraints, latest equipment in the field, Self contained, Direct Reading and Vessel Mounted Acoustic Doppler Current Profilers (ADCP) are of greater use to give very accurate current profiles. These (except Vessel Mounted ADCP) could be moored to the sea bottom facing up or can facing down from sea surface and can record data for a much longer period at 1 meter depth resolution.

The time series measurements of temperature profiles from boat is again at the mercy of the weather. Instead, moored 'thermister chains' can be provided to furnish temperature profiles for a longer duration. The temperature, salinity sensors of underwater moored systems like current meters, measure the parameters only at the depth levels where they are placed. The valuable information of sea Surface temperature could not be collected by them as there are limitations in their mooring depth. A 'Temperature-Depth Recorder' (under design and fabrication at NIO) would be of greater use as it can record time series temperature data for longer periods and extending to various depths starting from the very surface of the sea.

As there are several problems existing for observations at sea from small boats, more stress should be given to shore-based observations for the collection

of possible data. The surface currents for a very large area could be estimated with the most advance equipment 'Ocean Surface Current Radar'. It has transmitters and receiver arrays on the shore (approximately 20 km apart) and can sweep a large area of the sea surface to record surface current (through Doppler principle). Remote Sensing techniques are now widely used for various coastal area data collection. SST could be measured by using infra-red scanning, e.g Precision Radiation Thermometer' (PRT), from the land (but the data is limited to the very surface). Aerial photographs are also used for tracking drogues (for surface currents), studying dye patch movement, dispersion, coastal currents etc.

6. NECESSITY OF COASTAL OCEANOGRAPHIC DATA BANK

The diversity of Indian coastline is well known. It experiences a unique reversal of wind system in a year and the coastal wave/current characteristics are largely dependent on this. Thus the temporal and spatial variations in the coastal oceanographic parameters would be significant within a few kilometres along the coast.

Continuous monitoring of coastal oceanographic parameters and collection of meteorological data, at least for one year should be carried out as an intensive coastal ocean monitoring program. The data collected should include information on nearshore and coastal currents, tides, wave climate,

beach processes, quality of coastal water (temperature, salinity and dissolved oxygen), and primary information on coastal biota. The wind speed and direction, air temperature and rainfall data should also be collected.

Carrying out continuous monitoring to cover the whole diversities along the coast at a time may be impractical. Still efforts should be made to put up adequate number of field stations and collect significant data covering all the seasons. The data collected should be compiled, processed and stored in the form of a Coastal Oceanographic Data Bank. Further, any additional information available through investigations by other agencies should also be integrated into this bank.

This data bank would then be of immense use for solving coastal zone management problems. Once calibrated with the field data, the validity and applicability of the models would be very high. Users can at any time retrieve the data on useful parameters for study and application purposes such as marine outfall design, development of coastal structures and harbours, improving recreation facilities, pollution monitoring etc.

7. THERMAL DISCHARGES FROM POWER PLANTS

Now we will look into some aspects on the effluent discharges. The fundamental intent of waste disposal is to mix the effluent thoroughly with large

volumes of ambient water. Discharges through pipelines or shoreline discharges may not promote adequate mixing of the effluent, thereby increasing the stress on coastal waters confined to a small area. It has been shown by many investigators that the most effective way of effecting effluent dilution is through the use of a 'diffuser'. It is a pipe closed off at one end and having a supply of water at the other with holes of constant size along its side (ports) permitting water to discharge. The pipe diameter and hole sizes are such that a fairly uniform internal pressure is maintained throughout the length of the pipe resulting in equal flows from the ports. In the case of a coastal outfall, minimizing the surface concentration is often desirable, because if the discharge reaches surface (or discharged at the surface), it may be transported on shore by wind driven surface currents, possibly at a faster rate than the depth averaged current velocity. Similarly stress on benthos in the outfall area is likely to be more severe than that on other pelagic species and hence minimizing the sea bed concentration is also usually important. Thus it is suggested that the optimal discharge location is just below mid depth. The distance of

discharge point (Z_0) from bottom is given by the relation

$$Z_0 = 0.459 H$$

where H is the height of water column. In effect the site suggests a trade off between the strong shear/weak vertical mixing layer near the bed and the strong mixing/weak shear zone near the surface (Gabric, 1986).

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9. REFERENCES

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