

# SELECTION OF SITE FOR COOLANT INTAKE AND DISCHARGE OF SHORE BASED POWER STATIONS - COASTAL OCEANOGRAPHIC CONSIDERATIONS

G.NARAYANA SWAMY, A. SURYANARAYANA AND V. KRISHNA KUMAR

Coastal Ocean Space Utilisation Section  
National Institute of Oceanography  
Dona Paula - 403 004, Goa

## INTRODUCTION

Coastal regions support three quarters of world population; in India three of the four metropolitan cities are along the coastline. The electric power required for domestic and industrial use are best generated nearest to the consumption point to reduce investments and losses. This is one among many criteria for selecting power generating site. Thermal or nuclear power generation, being ultimately a heat exchange process, necessitates enormous quantity of cooling water. Sea offers unlimited source of water, engineering problems associated with seawater handling notwithstanding. Further, half of the surrounding area of a shore-based power plant falls over the sea. These form the rationale behind establishing giant power stations on the seashore.

In India there are two atomic stations on the sea coast presently - Tarapur and Kalpakkam. There are a few thermal power stations too along the Indian coastline. Phase II of Tarapur Atomic Power Station is on the way, as also another nuclear power project at Kudankulam, near Kanyakumari. A Fast Breeder Test Reactor too is contemplated at Kalpakkam. A nuclear fuel complex is expected near Tuticorin. Mangalore and Kayamkulam are going to have coal-based super thermal power stations. Kakinada is considered for gas-based power plant. Jaitapur near Ratnagiri is yet another site for nuclear power generation in future. All these units have to utilise seawater for cooling and/or disposal of ash, sewage, low activity radiowastes, etc. The dimension of the problem is thus multilevel.

However our knowledge of the environmental conditions of these sites is minimal and the perspective of the scenario when all the present, ongoing and future sites are operational is very limited. Generalisation of the experiences at one location to the other is often hampered by the site-specificity of the coastal oceanographic characteristics. Nonetheless a master plan for siting power plants, especially the intake/discharge points along our coastline is imperative. This paper will summarise the site-specific characteristics of a few shore-based power stations in the context of coolant water intake and

discharge, and examine some problems associated with thermal discharges from the oceanographic angle.

## CHARACTERISATION OF COASTAL SITES

We have carried out circulation and mixing studies of Jaitapur and Kudankulam<sup>1,2</sup> and have also reviewed the investigations of CWPRS off Tarapur<sup>3</sup>. Some experiences at Kalpakkam have been reported<sup>4</sup>. While some earlier reports give the oceanographic features off Tuticorin<sup>5</sup>, an extensive investigation is underway. There is hardly any field data for Mangalore and Kayamkulam sites. Kakinada is fairly known for its beach dynamics, but the circulation aspects are not well understood.

The primary parameters needed for characterisation of sites for coolant water intakes and discharges are : tides, currents, water temperature and salinity, air temperature and wind, bathymetry and sediment transport. These coastal oceanographic processes decide, individually and collectively, the thermal feature of the ambient sea and the behaviour of the thermal plume.

Tarapur is typical of large intertidal zone with extensive rock outcrops. Both tide and wind dominate the regime, leading to well-mixed conditions almost throughout the year. Here the alongshore and offshore spacing between the intake and the discharge should take care of both environmental and inplant requirements.

While Jaitapur site is characterised by moderate tides, systematic winds and currents, the adjoining creeks and promontories have definite influence on these. Water temperature variations too are definitive; and atmospheric temperature has shown local variabilities. Multiple possibilities exist here as to locating the intake and the outfall.

The presence of large rivers, estuaries and backwaters add more dimensions to the problem of wasteheat and ash disposal because of the vulnerability of the fresh water systems. Mangalore and Kayamkulam sites are distinctive in this respect. Further the adjoining sandy stretches might pose many other difficulties, as in the case of

Kalpakkam.

Despite moderate tides, currents and other oceanographic activities, the water intake/discharge system is hindered by excessive sand transport along, and possibly across, the shore at Kalpakkam. Vertical profile of water temperature and the bathymetry are such that cooler water could be drawn from a depth and the warm water be discharged at the surface, with the inherent inconveniences of course.

Being a bay with sand bars and sandy beaches, with connection to one of the major rivers, and exposed to the tropical cyclones, Kakinada would be a difficult regime.

Tuticorin may be similar to Madras coast except for the climate features such as higher temperature, lower humidity, meagre precipitation, etc. Oyster beds are susceptible to thermal damages.

Kudankulam near the southern tip of Indian peninsula is also close to a bioserve and is subject to the oceanographic influence of both the Bay of Bengal and the Arabian Sea. Tides being negligible, winds dominate the currents. Winds being strong and erratic, waves and currents too are unpredictable. Water temperature exhibit abrupt variations presumed to be the result of a large scale mass exchange.

## INTAKE AND DISCHARGE CRITERIA

The foregoing description would show the variety of these sites along the Indian coastline; field measurements alone could delineate the peculiarities of each location. The ambient characteristics and the behaviour of the thermal plume will determine the relative positions of the intake and the discharge structures of the coastal power plants. Prime importance is attached to the temperature of the receiving water body in the environmental perspective, whereas in the engineering perspective, the temperature of the intake water and the recirculation of the waste water into the intake thereby lowering the efficiency of heat exchange is of prime concern. Oceanographic problems and engineering solutions need not necessarily conflict though.

The temperature of the waste water from the condenser is usually about 10°C above that of the ambient water. The basic approach is to disperse the warm water in such a way that the area over which the specified minimum rise in temperature does not exceed a specified distance from the discharge point taking into consideration the tolerance limits of the local biota.

The incipient lethal temperature of most aquatic species

lies in the range of 30-35°C. In tropical climate where summer water temperatures approach this limit naturally, a further increase of temperature even by one degree may prove hazardous to many sedentary organisms. It is generally believed that the temperature of about 3-5°C above the ambient is the upper limit of tolerance of marine organisms in tropical seas. This will be adequate to safeguard the area outside the nearfield of few hundred meters, provided that physical conditions and outfall design allow rapid dispersion. It then becomes necessary in the tropics that the discharge temperature has to be brought down considerably within the mixing zone. In the past, for ocean sited plants the outlet has been a shoreline canal on the presumption that the warm water would spread over the surface layer and get cooled. Construction of such outfalls have now been forbidden elsewhere<sup>6</sup>; all new outfalls are designed such that the 2.2°C increment isotherm must not touch the shore or the bottom, and should not extend beyond 305 m from any part of the outfall structure more than 50% of any tidal cycle (values converted from FPS system). Current practice is to discharge warm water through multiport under-water diffuser system as they are more efficient than the surface discharge in maximising initial dilution and meeting regulatory requirements. This will also eliminate formation of pockets of warm water hugging the shore.

In a new concept for integrated rural development of coastal zone, clean cold water is to be drawn from deep sea (about 200 m) for condenser cooling. The discharge water with temperature close to that at sea surface can then be used for aquaculture, salt and marine chemicals, etc., thereby creating employment for local population<sup>7</sup>. Seawater cooling towers too are future possibilities.

## PREDICTIVE ASPECTS

The variety and variability of processes necessitate collection of field data from each site. Once the specific parameters are known, physical models form important tools for a clear assessment of the oceanographic set up. Mathematical models too are of considerable use for predictive purposes. The accuracy of these predictions however depends on the basic data inputs and assumptions.

Field data collection is largely limited by the instrumentation capabilities; precise, inexpensive, shore-based and weather-independent scanning systems are now available to obtain near-synoptic data. The major limitation of physical model is that it is difficult to simulate all features; dispersion is not easily amenable to scale-modeling. Wind, cross-shore currents and heating up of intertidal rocks during exposure cannot adequately be introduced in

the physical models. Numerical models too have limitations arising out of the non-amenability of certain physical processes to mathematical formulations. A composite approach based on all these three is the only solution.

No serious attempt has been made to predict the impact of heat waste on the local biota of Indian waters. Any amount of expertise in thermal plume mapping could only be vitiated by the lack of assessment of thermal impacts.

## CONCLUSIONS

1. The coastal oceanographic conditions prevailing at each of the power station sites along the Indian coastline are specific, requiring thorough field investigations.
2. Predictive capabilities are limited by the variety and variability of the processes; a composite approach is suggested.
3. No definite criteria have been evolved for the demarcation of a mixing zone or the impact zone as far as the thermal discharges are concerned; there are no substantial studies on the temperature tolerance limits of local biota in the tropical seas.
4. A master plan for industrial growth considering the combined impact of all coolant water intakes and outlets will be needed to avoid future operational and environmental problems.

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## A STUDY OF THE PREVALENCE OF ANAEMIA IN BRASSWARE INDUSTRY

S.K. RASTOGI, R.S. BHARTI, B.N. GUPTA, TANVEER HUSAIN AND SEEMA SRIVASTAVA

Epidemiology Division,  
Industrial Toxicology Research Centre,  
Post Box No. 80, Lucknow - 226 001, India.

A stratified random sample of 539 male workers engaged in brass-ware industry at Moradabad in northern India were surveyed, in a cross sectional study, for the prevalence of anaemia. The findings were compared with those obtained in controls. The study showed a significantly higher prevalence of anaemia among brassware workers than among controls (21.7% vs 5.5%;  $p$ ). However, no significant difference in the overall mean values of hemoglobin observed in the study population and the reference group could be found (12.4 1.3 gm % and 13.4 1.0 gm %). Among the different occupational

sub-groups (8.9 1.2 gm %) and the highest among the electroplaters (13.2 1.8 gm %). The sheet makers showed the maximum prevalence of anaemia (29%) while electro-platers suffered from minimum prevalence of anaemia (10.2%). The results also indicated a close relationship between the prevalence of anaemia and per capita income (PCI). The workers who had the poorest PCI (less than Rs. 100) exhibited the highest prevalence of anaemia (27.2%) while those having PCI between Rs. 400-500 showed only 7.1% prevalence.