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Environmental Impact Assessment for Thermoelectric Power Plants in the Coastal Zone

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1. Interaction of coastal power plants with the marine biota

Thermoelectric power-plants need a cooling system for condensating exhausted steam, after the phase of electricity generation. In the case of power stations built on the coast, the once-through cooling circuit operates with sea water, collected by pumps and discharged back to the sea, having removed the condenser heat and sometimes after a chemical anti-fouling treatment.

The effects of power plant operations on the marine environment, and particularly on biota, may occur both at the water intake and at the discharge structures.

The intake systems, when drawing cooling water, capture the living organisms with little or no swimming ability. The largest forms are retained by the screens that protect the circulation pumps and are washed back to the sea by cleaning devices mounted on the rotating screens.

Planktonic organisms are entrained through the whole cooling system, undergoing mechanic, thermal and chemical stresses, before returning to the marine environment.

At the discharge point, besides the delayed effects on the biological components that have passed through the plant, the effects on the organisms interested by the thermal plume of the effluent are taken into account.

2. Outline of environmental impact studies for marine power stations

ENEL pioneered environmental impact studies (E.I.S.) in the site of power stations, long before the existing legislative constraints. The experience gathered up to now has shown that a multidisciplinary approach is necessary in the case of marine biota analysis, in order to take into account the relations between biotic and abiotic parameters potentially influenced by the operation of power plants.

E.I.S.s are structured in a previsional phase, before the start of the project, and a monitoring phase, during the energy production of the plant.

In the first phase, the oceanographic and biological patterns of the surrounding area are described, and the expected physical and chemical perturbations are simulated, in order to identify the areas of concern and to estimate the magnitude of effects.

In the monitoring phase, selected organisms or communities are examined, which have been shown either directly influenced, or good indicators of ecological stability for a reasonably long time interval.

3. The case of a coastal power station

We have chosen the case of the previsional study for the Brindisi South power station as an example of the Italian approach to E.I.S.

The plant is located on the Southern Adriatic, has a total power of 2640 MWe, derives 100 m^3/s of sea water, and warms water +8°C in the condenser.

Geology and morphology of the bottom, sea currents, water and sediment quality have been described as the principal oceanographic features. Macrobenthos, plankton and nekton have been chosen as biological descriptors.

The impact assessment has been formulated by sub-dividing into elementary actions the plant project and its completion. Each action was to have effects separately analysed in qualitative or quantitative terms. Both the building and the operation actions were considered.

Estimations of biomass entrained or impinged on the intake structures were done with reference to an existing power station. Tri-dimensional mathematical models have been used to simulate the patterns of dispersion of the thermal effluent and of residual chlorine following anti-fouling treatment, given the oceanographic conditions prevailing in the area.

4. The case of an estuarine power station

The power station of Porto Tolle is located on the main branch of the Po River Delta, a few kilometers before its mouth, opening into the Adriatic Sea. It also consists of 4 standard units of 640 MWe, water derivation and thermal increase are similar to those in Brindisi. The station features two cooling circuits: the first, which is most frequently used, takes fresh water from the river and discharges downstream, the second can draw brackish water from a nearby lagoon and discharge directly to the sea.

The power station being situated in an area of great environmental value, the concern about possible changes brought about by its operation have stimulated a very thorough and long-lasting investigation. The environmental campaigns started in 1972, as soon as the project of the plant was approved, and continued through a pre-operational phase (1977-1980) and an operational phase (1986-1988). A five year long monitoring phase has been started in 1990. The hydrologic conditions received much attention, and gave interesting results, facing the difficult problem of the interaction of fresh and sea water, influenced by the rate of river discharge and by tidal currents. The measurement of the distribution of river flow among the different branches, the exchange of water between the lagoon and the sea, and the dispersion of the river plume in the Adriatic were used also to calibrate a physical model and several mathematical models. The prevision and the assessment of the distribution of thermal increase in the various water bodies helped to identificate areas for the assessment of biological and chemical properties.

Water quality was monitored, both from the point of vue of chemical hazards to aquatic life and of health protection. Phytoplankton and zooplankton communities and their temporal dynamics were studied in connection with hydrologic and chemical information. The macrobenthic assemblages dwelling in soft and hard bottoms gave useful indications about the evolution of the environment during the long term interval. Finally, fish communities were investigated, with special reference to migration of juveniles into the river branches and to commercial catches in the lagoon.

The overall comparison of results obtained in the pre-operational and operational phase revealed that the most important changes are most likely linked to the evolution of the environment under the anthropic pressure on the whole basin of river Po and are not attributable to the power station.

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Prediction of the Environmental Impact of Coastal Population on the Quality of the Sea

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The increase of coastal population -especieally by tourists- is something considered as flourishing of the socio-economic conditions of the district. Too little -if any- attention is given to the effects caused by this situation. In the present study taking into consideration the quality of the seawater as the main parameter affecting the population of tourists, an attempt has been done in order to predict the variation of the quality of seawater with population. To achieve that, the beaches were classified according to their use -and consequently the amount of wastewater discharged into the sea -into four groups: I)coasts that are used only for swimming and recreational purposes, II) coasts used simultaneously for dwelling, swimming and recreational purposes, III) coasts along which only dwellings exist, and IV) natural and man-made harbours.

Bodrum -one of the most popular touristic resorts of Turkey -was selected as the experimental site where six beaches; one from gorup I, one from group II, one from group III, two from group IV and one transitional group I-II, were selected as the survey areas. Three stations close to each other in approximately 10-20 meters from the shore were chosen for sampling. Samples collected at all three stations at each survey beach were mixed to obtain a typical composite sample. Samples were collected three times a day - early in the morning before people started coming to the beach; at noon when the beach was most crowded; and late in the afternoon when people started to leave the beach. During the survey 40320 observations were made between December 1985 to February 1988. Parameters such as atmospheric pressure, air temperature, cloudiness, sunny period, prevailing wind direction and its speed, precipitation, light intensity, turbidity, seawater temperature, pH, colour, salinity and coliform concentration were determined. Assuming the concentration of the total coliform as the most important microbial pollution indicator for beaches an attempt has been done for the determination of the variation of coliform concentration as a function of the remaining paratemers. To achieve this a multilinear regression program was used in which the number of total coliform was treated as the dependent variable while the others were accepted as independent variables. As a result of this analysis, the following relation was obtained:

$$N = \frac{(C_1 \sqrt{P} + C_2)}{10^{A-3}}$$

$$A = \frac{\ln(I^{0.29}\, T_u^{-0.072}) + 1.22}{0.95^{\theta-20}}$$

where

N is the number of total coliforms per 100 milliliters,
I is the intensity of light (lux),
Tu is the turbidity (FTU),
θ is the temperature of seawater (°C),
P is the population density (number of people/100m²),
C_1 is the population density coefficient and
C_2 is the coastal characteristic coefficient.

The coefficients C_1 and C_2 of this equation have been found to have the values given below:

Coast Group	C_1	C_2
I	15.7	0.020
I-II	78.4	0.223
II	220.5	0.682
III	281.7	0.293
IV	1310.5	2173.0

Parameters such as BOD, total nitrogen, total phosphorus etc. proved that they didn't contribute significantly to the total coliform concentration. The correlation obtained between actual determined values and the values estimated by the derived equation is above 86 percent.

The results obtained by this study is a significant contribution for the prediction of the environmental impact of tourist population to seawater quality and consequently for the prevention of the deterioration of the environment and protection of public health.

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