

tion in the secretory activity of Cell Type I has been observed which was correlated with the reproductive cycles of the oyster and the clam respectively^{7,12}.

Extirpation of the cerebral ganglia of *P. laterisulca* caused spawning in the matured clams of both the sexes while visceralectomized clams did not respond. This indicated that the neurosecretory material from cerebral ganglia had an inhibitory effect on the spawning due to the extirpation of the cerebral ganglia and a delay or inhibition of gamete emission owing to the visceralectomy. Nagabhushanam⁶ observed a direct relationship between the changes in the secretory material and the reproductive cycle in *Modiolus demissus*. He further observed that removal of the cerebral ganglia hastened the spawning in both the male and female mussels. Similar results were reported by Nagabhushanam⁷ in *C. virginica*.

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Uptake of Copper by the Mussel *Mytilus viridis* L.

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Effect of copper on survival and mortality of *M. viridis* has been investigated. Rate of uptake of copper is faster at concentrations higher than 0.1 ppm with mortality levels ranging between 12.5 and 75%. It is inferred that the rate of uptake may be the factor causing lethal effect.

BIOASSAY is a valuable tool in assessing the toxic effects of chemical wastes and is used for controlling pollution¹. Heavy metals like copper, in particulate or dissolved state, affect the meta-

bolism of the filter-feeding organisms adversely and these in higher concentrations prove fatal². Effectiveness of the heavy metal on marine organisms will also depend on their background concentrations in natural waters. Concentrations of copper reported are 3.41 to 76.12 µg/litre in the inshore waters along the central west coast of India, and 1.97 to 67.27 µg/litre in the estuarine waters of Goa³. In these areas, natural populations of mussels, *Mytilus viridis* L. occur in abundance.

Mussels used in experiments were collected from the rocky intertidal area of Velsao Bay, Goa. These were brought to the laboratory in plastic buckets and acclimatized for 7 days at a salinity of 33.5 ‰ at room temperature. They were not fed during the entire period of experimentation. The size range of the test animals was from 29 to 36 mm, with an average weight of 2.5 g. During the experiments copper was used in the form of hydrated copper sulphate, which is soluble in sea water at low concentrations. Stock solutions (1000 ppm) were prepared by dissolving copper sulphate crystals in deionized water. The concentration of copper used for the experiments were 0.01, 0.05, 0.1 and 1.0 ppm.

Toxicity and uptake experiments were carried out in 5 glass tanks (2 litres) using one as control and the rest as experimental. In each tank, 8 animals were kept in membrane filtered sea water with a salinity of 33 ± 1 ‰, under constant aeration. The water was changed every day to compensate for losses by adsorption on to the walls of the tanks. All the experiments were carried out at room temperature (26.5° to 28°C). Animals were taken after 24, 48, 72 and 96 hr or soon after mortality occurred whichever was earlier. These were kept in deep freeze prior to analysis for copper uptake. Atomic absorption spectrophotometer (Hilger & Watts) was used to measure the amount of copper present in the tissue. Copper in the shell was not considered. Methods employed for copper estimations were as those described by Topping⁴.

Table 1 gives the percentage mortality in 96 hr experiments. Small concentration (0.01 ppm) of copper was found to be ineffective as no mortality occurred. However, concentrations higher than 0.05 ppm proved fatal to the organisms. The mortality level was 12.5 to 25%. In the control animals copper was not detectable because the background concentration of copper in the sea

TABLE 1 — PERCENTAGE MORTALITY IN TOXICITY EXPERIMENTS

(Number of specimens per container was 8)

Copper conc. in medium (ppm)	Percentage mortality*			
	hr: 24	48	72	96
0.01	—	—	—	—
0.05	—	—	12.5	25
0.1	—	12.5	25.0	75
1	—	50	75	100

*Percentage mortality, nil in control (no detectable Cu conc.).

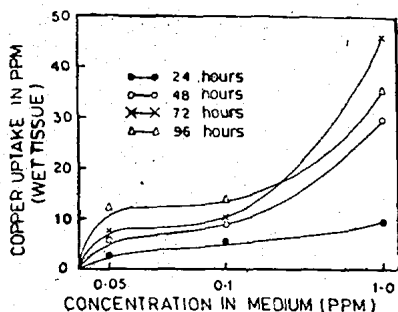


Fig. 1 — Uptake of copper by *M. viridis* in relation to copper concentration in the medium

water at Velsao during the season of spatfall of mussels was low and nondetectable. Uptake levels of copper from the medium at 24, 48, 72 and 96 hr (Fig. 1) revealed that the rate of intake of copper is faster in the medium containing concentrations higher than 0.1 ppm. Levels of copper in the tissues were related to their concentrations in the medium and also with time (Fig. 1). At low concentrations (0.05 ppm) the uptake was lower (7.50 ppm) and took more time (72 hr) than at a higher concentration (1.0 ppm) when it was greater (30 ppm) and took a shorter time (48 hr). In the 96 hr experiments, maximum uptake (47 ppm) was recorded when a 100% mortality occurred (Table 1).

From these experiments it is evident that time is a major factor in the uptake of copper leading to the death of mussels. At lower (background) concentrations of copper, shell fishes are known to accumulate the metal in their tissues, though not up to the level of mortality³. Galstoff⁵ reported that oysters contain from 1.24 to 5.12 mg/100 g of copper in their body. These concentrations are not toxic to the animals though they attain levels of about 100 times greater than what is found in normal sea water. McLusky and Philips⁶, while experimenting on the effects of copper on the polychaete *Phyllodoce maculata*, have found that copper concentrations reach to 567.8 ppm dry weight of animal tissue when the organisms were exposed to 0.06 ppm concentration for 3 weeks without any adverse effects. It is clear from the present study that greater the concentration of copper in the experimental medium, the faster will be the rate of uptake in terms of time.

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Microbial Flora & Dehydrogenase Activity of Beaches

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Heterotrophic bacterial flora of beaches, viz. Velsao (open sea beach receiving nitrogenous wastes from a fertilizer factory) and Dias (estuarine beach free from contamination) were studied. At Velsao, the organic carbon content in the sand was lower (0.18%) than at Dias (0.45%). Nitrate nitrogen content of the former was very high (619.36 µg at N/litre), as compared to the latter (4.52 µg at N/litre). Though Dias beach was rich in both terrestrial and marine flora (12.8 and 8.6 × 10³/g dry wt of sediment respectively), the percentage of proteolytic bacteria and nitrate reducers were more at Velsao. This indicates that the latter has a low organic carbon and high nitrogen content. Microbial flora was correlated with the dehydrogenase activity so as to determine the use of dehydrogenase activity as an index of beach pollution. Dehydrogenase activity at Dias was twice that of Velsao. The peak value was attained on the 5th day of incubation in samples from Dias (0.54 mg/g dry wt sediment) and on the 3rd day in samples from Velsao (0.26 mg/g dry wt sediment).

INDUSTRIAL wastes discharged into the sea induces changes in the ecosystem by changing its chemical and physical properties and its microbial flora, which then react with the pollutants either favourably or adversely. To understand this phenomenon, bacterial population as physiological groups has been studied in relation to ecological factors in a beach at Velsao which has a fertilizer factory in its vicinity and in another beach, Dias near NIO which is free from such pollution. The role of dehydrogenase in a beach ecosystem has not been reported so far. In the present study an attempt has been made to compare bacterial flora with dehydrogenase activity in these two beaches with a view to finding out whether this activity can be an indicator of beach pollution.

Random sediment samples were aseptically collected (June 1975) from the beaches and transferred to the laboratory in ice.

Isolation of bacteria — The samples were mixed and subsamples were taken for studying the bacterial population. Serial dilution method was followed to plate bacteria employing nutrient agar and Zobell 2216 E. Plates were incubated at room temperature (26°C ± 2) and bacterial counts recorded after 48 hr. Morphologically different colonies were isolated, purified and physiologically grouped¹.

Organic carbon of the sediment was estimated using the method described by Wakeel and Riley². Particle size analysis was made following wet sieving technique³. Interstitial waters collected from the sampling areas were used for the determination⁴ of salinity, oxygen, nitrite-N and nitrate-N.

Dehydrogenase — Dehydrogenase activity was determined by following the reduction of triphenyl-tetrazolium chloride (TTC) to triphenyl formazan.