INTRODUCTION

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In recent years, pollution in general and sea water pollution in particular, has become an important topic for national and international considerations. Because of its impact on society, marine pollution has attracted great attention from politicians, administrators, natural scientists and technologists all over the world.

To save our environment from further deterioration, it is essential to have an assessment of this problem. Pollution is the result of industrialization and technological achievements, but its increase is also correlated with the rising population. The need for pollution monitoring and control in countries undergoing rapid industrialization is well established because of the tendency for environmental concerns to be ignored in favour of rapid development and due to the lack of antipollutional legislation or laws and inability to enforce such laws.

Coastal zones are more prone to vulnerability of pollution, as this zone receives pollutants both from land and waters and major developments in industries, transport and other maritime activities causing pollution tend to take place in the vicinity of coastal zones. Besides, coastal areas are densely populated and coastal ecosystems are fragile by nature due to their high degree of variability in space and time. Conservation of this zone demands paramount importance as these are important areas for fisheries, including shell fisheries and are nursery areas for off-shore fish stocks. Coastal area dumping grounds have a much higher pollutant concentration not only because the material is being put into these shallow areas much more rapidly than it is being carried away by natural water motions, but

also because of the normal structure of the oceans which tend to prevent the mixing of these inputs with the rest of the oceanic volume (Williams, 1979). Hence pollution levels of coastal sea water need to be constantly monitored to establish an early warning system and to yield standardised data for environmental management.

Among the various animal groups, the use of mussels or clams as sentinels of pollution is currently gaining importance. It appears to be generally accepted that enough is known to pursue a productive programme of coastal pollution-monitoring using the 'mussel watch' strategy. In the development and application of the sentinel organism concept for pollution-monitoring, an integrated and interdisciplinary approach to the management of these complex pollution problem is imperative. In this context, it is a pre-requisite to take stock of the information available and the state-of-the art prevailing in the country at present. For assessing the total biological effects and long-term consequences of pollution on aquatic organisms it is essential to collect available and relevant information on possible sentinel species. The class bivalvia is of interest to toxicologists, as it comprises sedentary, filter-feeding invertebrates which are likely to accumulate pollutants from the environment and demonstrate clearly, the deleterious effects of its changing surrounding.

It is no longer sufficient to document marine pollution in terms of the chemical concentration of the contaminant. The use of bioassays as part of a comprehensive approach to marine pollution assessment is widely accepted nowadays. Toxicity is a biological response, which when quantified

in terms of the concentration of the toxicant can constitute the basis for a bioassay procedure. Bioassay (=toxicity) tests are defined here as estimation of the amount of biologically active substances by the level of their effect on test organisms (Chapman and Long, 1983). The majority of present bioassays are concerned with determination of survival related to effluent or single aqueous toxicant concentration. Information generated from various toxicity tests can be of use in the management of pollution for different purposes like, prediction of environmental damage of a waste; comparison of various toxicants, animals or test conditions and regulation of waste discharge.

In general, sublethal effect covers, the effect of all those concentrations which are not lethal for individuals even after prolonged exposures, but increases the population mortality, decreases its size or changes in composition. Thus a group of effects that affect the growth rate, metabolism, reproduction or which impair the defence mechanism of an organism are referred to as sublethal effects. In the present investigation sublethal effects of pesticides and water accommodated fractions of Light Diesel Oil and Persian Gulf Crude oil on two selected bivalves were looked into in detail. Physiological/behavioural responses like rate of filtration, oxygen consumption and byssogenesis are the parameters used for the assessment of the sublethal effects.

In the process of the seas and estuaries around us becoming the ultimate sink and as the problem of pollution being multifarious, it is unlikely that a toxicant occurs singly in the surrounding. Sprague (1970) remarked, "probably the most exciting and potentially useful recent development in pollution biology has been a method of predicting toxicity of mixtures of

toxicants". Recently the concept of prediction of toxicity of mixtures of pollutants has received wide approval in aquatic toxicological studies as it provides scope to study simultaneous effects of several pollutants in a single set of experiment, the result of which can be expressed as a single number.

The present study involved investigation of the lethal and sublethal effects of four pesticides and two petroleum oil, individually and in combinations on two commercially important bivalves. Among the four pesticides used two are organophosphates and the other two are organochlorines. Synthetic pesticides, especially organophosphates and organochlorines have become increasingly important additions to chemical wastes polluting natural aquatic communities. Many of these are considered hazardous because of their ability to kill or immobilize organisms even at very low concentrations.

Most pesticides are synthetic chemicals and could be classified by chemical types. Organophosphorous pesticides (o.p) or simply organophosphates are esters of phosphoric, phosphinic or phosphonic acid. Ekalux^{R} and Dimecron^{R} are the two organophosphates used in the present study.

Organochlorine pesticides also known as organochlorines or simply as o.c.s. consist of two different major groups based on their molecular structure; namely the cyclodiene or diene group and the DDT group. Cyclodiene group are cyclic groups with characteristic 'endomethylene bridged' structure. With the exception of Toxaphene, all the cyclodiene insecticides are the Diels-Alder reaction products of hexachlorocyclopentadiene and a suitable unstable compound. DDT and its analogues, that contain two aromatic rings represent the second group in organochlorines (Lee et al., 1977).

Among the two organochlorines used in this study Aldrex^{R} belongs to diene group and DDT^{R} belongs to DDT group.

Most of the pesticides are neurotoxins and their effect on animals is manifested through the nerve tissue, inhibiting or poisoning cholinesterase, an enzyme which is essential to the orderly operation of the nervous system.

There are several sources for the hydrocarbons found in marine samples (Farrington et al., 1976). Petroleum is an extremely complex mixture of thousands of different hydrocarbons and related compounds. When exposed to oil-contaminated sea water, marine animals rapidly accumulate in their tissues a wide spectrum of petroleum hydrocarbons (Neff and Anderson, 1975., Gilfillan et al., 1977; Neff and Anderson, 1981) and concentrate them to a marked degree over sea water levels. The lethal as well as sublethal effects of the water accommodated fractions of two petroleum products, Light Diesel Oil (LDO) and Persian Gulf Crude (P.G. Crude) are assessed in the present investigation. Many of the components of the petroleum fractions are carcinogenic agents, which combine with various cellular constituents, so that the heritable cellular physiology is altered. Moreover, it is likely that pesticides being lipophilic, combine with the oil fraction to produce a combined effect which might be rapdily toxic and more lethal to the biota. Therefore, special attention is given in the present investigation to delineate the combined toxic effect of oil and pesticides.

The results are presented under different sections to make the presentation meaningful. This sort of investigation will eventually open up a very interesting aspect of toxicology, the understanding of which would help in

delineating the impact of contamination by pesticides and oil, individually and in combination on the intertidal and subtidal biota of the coastal ecosystem.