Table 5. Habitat/microhabitat distribution of the 171 species of flowering plants

Type	Number of species	Percentage
Epiphytic	13	7 6
Stream banks	16	9 4
Rock crevices with humus	17	10.0
Humus on forest floors	10	6.0
Ecotones	6	3.5
Not specified	109	63.7

at least during the recent history, a general impact on these plants can also be the dessication brought about by canopy opening in the humid forests, where they occur.

The above analysis based on the available data on endemic, rare and endangered plants of south India has highlighted a few important issues. First, certain families tend to have more number of rare and endangered plants than the others (phylogeny). Second, physiognomic categories such as trees and shrubs (woody plants) tend to be more vulnerable to extinction than the other forms. Third, although the data are limited, geographical restrictedness (endemism), altitude, vegetation, habitat and microhabitat specialization apparently have an influence on the status of plant species. Further information on the distribution and status would be of great value while outlining conservation strategies for flowering plants.

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Marine pollution in India: An emerging problem

G. P. Glasby and G. S. Roonwal

With a population growth rate of about 2% p.a. and an economic growth rate of about 4% p.a., India is likely to face increasing environmental problems and chemical pollution in the future. The seas are the ultimate receptacle for land-based pollution and it is interesting to assess the stress on coastal seas caused by this pollution. A number of scientific papers have been published on this topic[1–9] and this article attempts to summarize some of the major findings

India has a coastline of about 7500 km with about 25% of its population living in coastal areas. Many major cities are located along the coast, including Calcutta, Madras and Bombay. In all, there are 11 major, 16 intermediate and 78 minor ports in India. India is one of the wettest countries in the world, with an annual rainfall of 1000 km^3. There are 14 major, 44 medium and 162 small rivers in India, with a mean annual runoff of 1645 km^3, although not all these rivers discharge into the sea. About 500 million tonnes of sediment are discharged into the seas each year from India. A unique feature of the Indian Ocean is the monsoons. In the Arabian Sea, the SW monsoon results in intense upwelling along the west coast of India and this accounts for the high productivity and fisheries potential in this area. The Arabian Sea and the Bay of Bengal are subject to large semi-diurnal tides with amplitudes of 1–8 m and are also influenced by the biannual reversal of the monsoon winds. These two factors result in the flushing of Indian coastal areas which helps in dispersing pollutants. The study of coastal ocean monitoring and prediction system by the Department of Ocean Development is useful to monitor coastal marine pollution. This study shows that the open oceans around India are pollution-free[10]. Nevertheless, coastal pollution is an increasing problem in India and we therefore record some of the major sources of pollution.

Domestic sewage

Domestic sewage is perhaps the major pollutant in coastal areas of India. Some 4.4 km^3 of such wastes are discharged into the seas off India each year. For example, Bombay discharges 365 million tonnes of sewage effluent to the sea annually and Calcutta about 396 million tonnes. Perhaps the major problem in India is that only a small proportion of this sewage is treated before discharge The situation could improve when the

tertiary-level treatment plants and the 3 km sewage outfalls are completed in Bombay, and the Ganga Action Plan is implemented. Nevertheless, upgrading sewage treatment facilities would be the greatest single contribution to the reduction of coastal pollution in India.

As an example of the problem, Mahim Bay in Bombay occupies 64 km^2 and once had a healthy ecosystem with fisheries, oyster beds, mangroves and migrating birds. It is now one of the most polluted areas in the country. The dissolved oxygen levels in the water of the Bay sometimes fall below 1 mg/l and hydrogen sulphide (denoting anoxia) can be detected depending on the stages of the tide. Water has high nutrient contents (denoting eutrophication), high biological oxygen demand and high colliform bacteria counts. The nearshore waters display severe organic pollution, especially during ebb tides, resulting in low biomass and a fauna consisting mainly of species from low trophic levels. Essentially then, Mahim Bay is an open sewer which may affect the health of the local communities.

In addition, the benthic fauna of Bombay is badly depleted, resulting in the loss of fisheries. Fisheries are retreating from shore and fishermen now have to go at least 10 km offshore to get a worthwhile catch. The main health hazards for humans are gastrointestinal diseases resulting from the consumption of contaminated sea food.

In the long run, there is another threat. Because of the high productivity of the surface water of the Arabian Sea caused by upwelling of deep sea-water, the intermediate-depth waters off the west coast of India are poor in oxygen and have a renewal time of only four years. As a result, these waters may be vulnerable to perturbation, either by an increased flux of organic carbon from pollution or an increased productivity of surface waters caused by climatic change. In either case, this could lead to these waters becoming completely anoxic and lifeless, with major implications.

Industrial wastes

About 0.44 km^3 of industrial waste are annually discharged into the seas around India. Many industries such as paper, textile, chemical, pharmaceutical, plastic, food, leather, jute, pesticide and oil contribute to this waste and particular attention needs to be paid to heavy metals like lead, zinc, cadmium and mercury, and also to elements such as chromium used in the leather industry. In general, the concentrations of these elements in sea-water, sediments and biota in offshore areas do not pose a problem. Discharge of these elements into the rivers also tends not to cause major problems to the marine environment. For example, 55% of the metals discharged into the Ganges settle out in the estuarine and river mouth region and only 15% reach the Bay of Bengal. Nonetheless, the problem remains in the coastal areas near big cities. In Mahim Bay and Thane Creek, Bombay, the concentrations of heavy metals in marine organisms are quite high, indicating environmental degradation to an extent that some marine species are unfit for human consumption. An estimate has been made of heavy-metal discharge into the Ulhas River, which drains into Thane Creek in Bombay. The estimate was based on monitoring of 18 of the 48 major industries operating in the region. It showed that 11 tonnes of Cu, 400 tonnes of Zn, 7 tonnes of Hg and 0.5 tonnes of Cr are discharged into the river annually[11]. This explains the massive impact on Thane Creek.[3]

A major source of metal pollution in India is fly ash from power stations. Over 100 million tonnes of fly ash are produced each year and much of it is transported in the atmosphere before deposition. It is a major source of contamination of heavy metals such as cadmium in the rivers and estuarine sediments in the vicinity of such power stations.

Other sources of metal pollution include drainage water, weathering of spoil heaps and anti-fouling paints used to paint fishing boats and trawlers.

Pesticides

A total of 381,000 tonnes of pesticides and other halogenated hydrocarbons are used in India each year, of which 55,000 tonnes are used in agriculture. The total annual consumption of DDT and its isomers is 107,000 tonnes per year.

These chemicals have two principal applications, as pesticides, herbicides and fungicides in agriculture and in the control of vector-borne diseases such as malaria.

These compounds are extremely persistent in the environment and the seas are their ultimate repository. It is believed that up to 25% of the DDT used to date may have been transferred to the sea. In India, pesticide concentrations are much higher on the east coast than on the west coast and are transported there by the large rivers on the east coast. These compounds have a demonstrable impact on marine biota and result in reproductive failures in birds and fish and inhibition of photosynthetic activity.

It should be emphasized that the terms pesticides, herbicides and fungicides are a misnomer. These compounds are in fact *biocides*. Their indiscriminate effects on biota have been well known for over 30 years and are well documented in Rachel Carson's classic book *Silent Spring*. The impact of DDT on wildlife is particularly damaging and this is the main reason that it has been banned in most western countries. In India, DDT is used principally for malarial control. However, despite a substantial initial impact and helping to bring down new malarial cases to about 200,000 per year, there are now over 2 million new cases per year as a result of mosquitoes becoming resistant to DDT. Doubt has now been cast in the efficacy of DDT in the control of malaria.

In India, huge quantities of biocides are used each year and there is a clear need to reduce reliance on them, particularly DDT, which should be banned outright as it is a dangerous chemical. In the west, much effort is being directed into the development of biodegradable pesticides. Although these are more expensive chemicals than traditional ones, there is an urgent need to review India's excessive reliance on biocides in the cause of environmental restoration.

Oil

One of the main tanker routes for the transport of oil is from the Gulf to the Far East through the Arabian Sea. Apart from tanker accidents and oil well blowouts, the main sources of oil pollution in the marine environment are ballast discharge and bilge washings. The occurrence of oil slicks and tar balls along this tanker route are well documented. The tar particles have a residence time of 30–45 days before they start sinking and tar-like residues are washed up on the west coast beaches of India, particularly during the SW monsoon. A peak of about 750–1000 tonnes of oil deposits was recorded on these beaches in the

mid-1970s. This type of pollution appears to have levelled off or even decreased since then as a result of a decrease in the volume of oil transported along these routes. In any case, vigilance is required to control such pollution.

Summary

The preceding sections have reviewed the main sources of marine pollution around India. The list is by no means complete. For instance, it does not mention the impacts of (i) soil erosion and land reclamation, (ii) disposal of solid wastes (litter), (iii) mining, (iv) modification of the hydrocycles of rivers by dams, and (v) the siting of nuclear power plants on the coast. Similarly, the impact of this pollution on sensitive environments such as estuaries, coral reefs and mangrove forests is not discussed. It is however clear that this is a major problem. The main areas where offshore pollution occurs in India have already been identified and initial work needs to concentrate in such areas.

It has been argued that environmental contamination is the inevitable consequence of human civilization and a natural phenomenon[4]. While this is true, the fact is that we now produce and discard huge volumes of material much of which is synthetic in origin and not biodegradable. It can be argued that India with its 3000 years of civilization based mainly on agriculture, always was a throwaway society. This was perfectly legitimate when biodegradable wastes were being discarded. However, the widespread use of plastics and chemicals, particularly over the last 50 years, has changed the situation drastically necessitating a radical revision of ideas on waste management.

In particular, it is essential to install and upgrade sewage treatment plants in the large cities and would probably result in the biggest single improvement of the environment in India. For industrial wastes, industrial sewers need to be installed. However, modern industrial plants in the west are making major efforts to reduce the discharge of pollutants into the environment and major cutbacks can be achieved by the installation of appropriate technology. Of course, this approach is capital-intensive but it also requires a different mindset in considering the problems involved.

One argument is that the disposal of untreated wastes to the environment is essentially free and that pollution control is an unwarranted expenditure which erodes industrial competitiveness. However, much effort in the West is directed precisely along these lines and it is found that, where operations are optimized, cost savings can be made. Furthermore, the former communist countries of Eastern Europe, where rapid industrialization was accompanied by minimal pollution controls, are now faced with enormous bills for their folly. For instance, it has been estimated that the costs of cleaning up the Baltic Sea and the Vistula River in Poland will be of the order of US $ 18 billion and US $ 3 billion, respectively, over a 20-year period.

The implication of all this is that, in the long term, a policy of indiscriminate discharge of waste into the environment is not necessarily the cheapest option and that environmental clean-ups can be extremely expensive when forced on society, for example, by regulation or in response to health threats such as epidemics or metal poisoning. The real task facing India therefore is to reduce the present throwaway culture which pervades the society and to upgrade waste management systems which are presently well below acceptable levels in order to minimize the future problems. Particular emphasis should be placed on the development of new ways of thinking about the use and disposal of chemicals and wastes. Otherwise, the costs of environmental clean-ups in the future may be much greater than ever anticipated.

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Localized chaos on periodic orbits

Boldrini[1] has referred to classification and common noun as two cornerstones of science. He has added that one undesirable effect of classification is to suppress mathematically the variability ubiquitous in the events in the physical world. Classification and common noun impose a subjective reality which leads to inadequate or improper description and one must be alert to the necessity of reconsidering the linguistic expressions so that the underlying concepts are suitably