Introduction

Natural products constitute the best possible library with maximum possible diversity of chemical structural types. With the advent of modern tools they have been eminently screened. Based on traditional use or modern studies natural products contribute 85% of the treatment regimes of 80% of the World’s population. The chemical complexity of the complex natural products till now thought to be a disadvantage for drug discovery can now be considered as an advantage for the drug development.

The oceans are full of living organisms and contain more flora and fauna compared to the land\(^1\). In the course of evolution, marine organisms have adapted excellently to the marine environment, such as high salt concentration, low temperature, high pressure and low nutrient availability. These extreme conditions require unique adaptation strategies leading to the development of new natural products, which differ from known structures of terrestrial organisms\(^2\). About 7000 marine natural products have been isolated so far, 25% of which are from algae, 33% from sponges, 18% from coelenterates (sea whips, sea fans and soft corals), and 24% from representatives of other invertebrate phyla such as ascidians (also called tunicates), opisthobranch molluscs (nudibranchs, sea hares, etc.), echinoderms (starfish, sea cucumbers and others) and bryozoans (moss animals)\(^3\).

Although research on marine natural products started only about 50 years ago, marine organisms have been used in traditional system of medicine much before that. In most countries with ancient civilizations, such as India, a system of medicine, indigenous to the country concerned, exists. In spite of all recent advances in medicine, indigenous medicine still caters to the needs of a large section of the population\(^4\). Knowledge gained over trial and error over thousands of years in India has been systematized as different systems in Indian Medicine\(^5\). These drugs are used singly or in simple combinations or as compounds referred as polypharmaceuticals. The forms in which these are used are varied like extracted juices, decoctions, infusions, distillates, powders, tablets, pills, confections, syrups, fermented liquids, medicated oil, bhasmas (ash) and many more\(^5,6\).

Drug discovery and development from the Ocean was initiated about 50 years ago with the discovery of the sponge-derived nucleosides spongothymidine and spongouridine\(^7\). Since then well over 14,000 different natural products from marine organisms have been described\(^8\) and hundreds of patents describing new bioactive marine natural products have been filed\(^9\). Approximately 10-15 different marine natural products are currently in clinical trials mostly in the areas of cancer, pain or inflammatory diseases\(^10\).
Medicinal Marine Organisms

1. Sponges, *Spongia officinalis*

Sponges occur as a light lump of porous nature and they are yellowish-brown, soft, elastic and irregularly shaped. Divers collect them from submerged rocks to which they adhere. When fresh, they are covered with a gelatinous substance that must be removed to prevent putrefaction. Dry sponge consists of gelatine, albumin and iodine. Its ash is obtained by burning the sponge in a closed vessel and used as deobstruent and astringent. Mixed with oil it is applied to swollen glands (goitre). It is also given internally in treating dysentery, diarrhoea, ulcers, puerperal sepsis and many diseases for which it is used in Ayurveda17, 18. In Siddha system of medicine, coral is a valuable drug with multifarious uses. Root (*Bikhe Marjan/Bussud*) and branch of coral (*Shakh-e-Marjan*) are used separately for different medicinal purposes. Internally it is constipatory, astringent, styptic, antidiarrhoeic, diuretic, urinary antiseptic, detoxicant and general tonic. It is useful in treating melancholia, epilepsy, insanity, palpitation, enlargement of spleen, gastric disorders, renal calculi and piles. It is recommended in treating stomatitis, haemoptysis, cough, phthisis and asthma. The ash is used as a tooth powder for strengthening gums and teeth, as *surma* for treatment of eye diseases, as eardrops with oil for alleviating ear ache and as an aqueous lotion in leprosy9. It is also used for treating anaemia, high fever and haemolytic jaundice16.

In Unani system of medicine, coral ash is used as a local astringent, styptic, antidiarrhoeic, diuretic, antispasmodic, and as deobstruent. It is used in treating piles, haemorrhoids, piles and constipation. In Siddha system of medicine, coral is mentioned as *Pavalam* and *Pavalam* based drugs have been claimed to cure loss of appetite, polyphagia, delirium, oligospermia, eye diseases, rickets, diabetes mellitus, skin diseases, ulcers, puerperal sepsis and many diseases for which it is used in Ayurveda17, 18.

In Unani system of medicine, coral ash is used as a local astringent and styptic. It is used in treating piles, haemorrhoids, piles and constipation. In Siddha system of medicine, coral ash is used as a local astringent, styptic, antidiarrhoeic, diuretic, antispasmodic, and as deobstruent. It is used in treating piles, haemorrhoids, piles and constipation.

2. Corals

Corals are of varied types and are exclusively marine. Two types are used commonly in medicine. One is a porous lumpy variety and the other is a slender precious variety. Both are red in colour due to a pigment. Corals contain mostly calcium and small amounts of magnesium, iron and phosphorous. Calcined corals are used in treating piles, coughs and tuberculosis12. The lumpy variety is cheaper while the slender variety is expensive. Lumpy porous variety is called coral root and the slender variety, coral branch in English13. In the Ayurvedic system, the ash form of corals, popularly known as *Pravala Bhasma* has been used in treating cough, phthisis, pulmonary tuberculosis, asthma, chronic bronchitis, fever, urinary diseases, spermatorrhoea, gleet and gonorrhoea, carbuncle, scrofulous affections and as a tonic against headache, giddiness and vertigo11. Coral ash is also used as a local astringent in the preparation of tooth powders, in preparations for the treatment of cancer of breast, lungs, stomach and uterus14, anaemia, and haemolytic jaundice15. It is used in reducing inflammation, dysuria and oliguria16. In Siddha system of medicine, coral is mentioned as *Pavalam* and *Pavalam* based drugs have been claimed to cure loss of appetite, polyphagia, delirium, oligospermia, eye diseases, rickets, diabetes mellitus, skin diseases, ulcers, puerperal sepsis and many diseases for which it is used in Ayurveda17, 18. In Unani system of medicine, coral ash is used as a local astringent, styptic, antidiarrhoeic, diuretic, antispasmodic, and as deobstruent. It is used in treating piles, haemorrhoids, piles and constipation. In Siddha system of medicine, coral ash is used as a local astringent, styptic, antidiarrhoeic, diuretic, antispasmodic, and as deobstruent. It is used in treating piles, haemorrhoids, piles and constipation.

3. Molluscs

4. Crustaceans

**Crabs**

Oil extracted from crab’s flesh is used as one of the ingredients in preparations used in treating Otorrhea, Otitismedia and ear troubles in Siddha medicine18. The crab, *Scylla serrata* has antibilious, diuretic, laxative and haematemic properties and is a cardiac stimulant21. The Santal tribal from Andaman and Nicobar Islands in India use crabs to cure vomiting in infants and puerperal fever22.

**Crab fossil**

This consists of fossilized remains of crabs available in some South Indian localities. A calcinated residual fine powder of crab fossils is given as a specific medicine in urinary obstructions and lithiasis12.

4. Molluscs

**Pearl oyster**

Pearls are calcareous concretions formed as protection against irritation caused by foreign objects, which lodge inside between the mantle and shell of pearl oysters. Pearls have been used in medicine by the Ayurveda and Unani physicians from ancient times. Pearl oysters of marine origin belong to a single genus, *Pinctada*. In general, pearls are considered to possess antacid and tonic properties and are mostly used in the form of pearl ash (*Mukta bhasma*), obtained as a result of powdering or calcining the pearls22. In combination with other medicines, they are prescribed in treating tuberculosis, jaundice, dyspepsia and urinary complaints23. The calx is a stimulant, tonic, antacid and aphrodisiac12. The shell of Mother-of-pearl is used in medicine. Medicinally its flesh is acrid, demulcent, palatable and beneficial in phthisis and heart diseases. The ash (*Sukti bhasma*) of the Mukta-Sukti (pearl oyster) a kind of shell is...
beneficial in treating dyspepsia, abdominal tumours, liver and spleen enlargements and loss of appetite. The lime obtained by burning hard cover has the same properties as that of Sukti-bhasma\textsuperscript{11}.

Pearls from the back lip oyster, \textit{Pinctada margaritifera} are purified by boiling in the juices of \textit{Sesbania cannabina} (Retz.) Pers. leaves or flowers of \textit{S. grandiflora} (Linn.) Poir. It is then calcined in covered crucible and finely powdered for medicinal use. This powder is cleaned by rubbing it with the juice of \textit{Rumex vesicarius} Linn. and then transferred to a lemon and stowed in a mass of paddy. After one week, it is heated in a crucible and ashed. The powdered ash is a stimulant and tonic and acts as an aphrodisiac. Pearl ash is chiefly carbonated oxide of lime and acts also as an antacid. The ash (\textit{Mukta bhasma}) is used in treating heart-burn and bilious affections. \textit{Mukta bhasma} given twice a day with honey is useful in treating cough, phthisis and asthma. Its chief use is in low fevers giving rise to burning sensation in the eyes, palms and soles. It reduces the yellowish tinge in the conjunctivae and in urine due to low fever and reduces the burning during micturition. It is also used as a cerebral tonic in nervous diseases such as chronic headache, epilepsy and other convulsive attacks. It is used to treat piles, leucorrhoea and spermatorrhoea and impotence. The powder is one of the ingredients in numerous Indian preparations used for treating impotence, heart disease, consumption (pulmonary tuberculosis), etc. \textit{Pittantaka rasa} (a preparation) made from pearl ash together with several other substances is useful in controlling diseases caused by deranged bile (\textit{pitta}) such as dyspepsia, jaundice, biliousness, vomiting of bile, etc. Another preparation containing pearls known as \textit{Vasantakusumakara rasa} given with sugar, honey and ghee is used in treating urinary diseases, impotence, gleet, diabetes and general debility. This medicine is a valuable alterative tonic in chronic gonorrhoea and spermatorrhoea and is prescribed in these complaints in combination with an extract called \textit{Kusavaleha}. For seminal weakness, a pill made up of \textit{Mukta bhasma} and red coral \textit{bhasma} is used. A concoction made up of 29 ingredients among which pearl is one is used as a tonic to strengthen cardiac muscles and the central nervous system. A powder prepared with pearl ash as one of its ingredients is used in treating general debility, leucorrhoea, diabetes, etc\textsuperscript{11}. \textit{Pinctada margaritifera} alkaline ash in calcined state also serves as an antacid in heart burn and bilious affections\textsuperscript{24}.

Pearls found on the southern sea coasts of India are said to be more useful in medicinal purposes\textsuperscript{25}. Pearls have also been used in the Siddha system as a treatment in all kinds of fevers, brain or nervous symptoms, opacity of cornea, cataract, keratitis, iritis and in all kinds of eye diseases including night blindness and colour blindness\textsuperscript{18}. The pearl powder is used generally in treating urinary diseases, constipation and to increase strength, nutrition and energy\textsuperscript{24}. Pearls have also been used in several Ayurvedic preparations for the treatment of cough, phthisis, dentitional fever, weakness of heart and mental disorders\textsuperscript{16}. It is also known to promote strength and intellect and enhance semen production. It alleviates burning sensation in eyes, eye diseases, bronchial asthma and cough\textsuperscript{26}. Pearls are one of the ingredients of Ayurvedic preparations in the treatment of throat cancer\textsuperscript{14}. In Siddha medicine, preparations in the form of calx/bhasmam are used in treating of glycaemia and glycosurea, and diabetic neuropathy\textsuperscript{27}. In the Unani system of medicine, pearl, known as \textit{Mervareed}, is used in treating heart weakness, myocardial degenerations, anaemia, neurosis, palpitations, tuberculosis and habitual abortions\textsuperscript{30}.

**Edible oyster**  
\textit{Ostrea gryphoides} (Saccostrea gryphoides Schl.) is a shell fish found in the Atlantic and Indian Ocean coasts. It has a small, hollow, ovate excavation in which the animal with a soft, fleshy sub orbicular body is enclosed. The shell has a hinge at one end and opens into two valves; one shallow and the other deep, which is found adhering to the rock. The shell is hard, externally grey or dark-brown, rough and marked with lateral undulated streaks; internally it is white, smooth and shining. It contains calcium carbonate (85 to 95\%), phosphate and sulphate of calcium and magnesium, iron oxide, alumina and silica. The inner layer is chiefly used in preparing the ash, called \textit{Kalu bhasma}. The ash is antacid and alterative and is used in treating cases of diarrhoea and chronic intestinal disorders. This animal is supposed to possess aphrodisiac properties and is therefore, eaten raw or cooked. A paste of the shell is used as an absorbent for the same purposes as the other shells.

Oyster shells are used in Siddha preparations for treating Otorrhoea, Otitis media and ear troubles\textsuperscript{18}. The Ayurvedic
text Sushruta Samhita mentions the use of shells of marine oysters and pearls in eye-salves in ophthalmic and other ocular infections.

5. Gastropods

Conch

Conch is the empty shell of *Turbinella rapa* or *Xanchus pyrum*, a marine gastropod. It is a source of calcium salts. Conch is known as *Sankha* in Indian medicine and *Sankha bhasma* prepared by incinerating the conch shell is used in treating dyspepsia, digestive impairment, malabsorption syndrome, enlargement of liver-hepatomegaly, hyperacidity and duodenal ulcer. The flesh of this animal, used as an anodyne, is nutritious and is a cardiac stimulant. It is also used in asthma, phthisis and tumors. *Sankha bhasma* (Conch shell ash) is used for earache, ulcers, and eye troubles and is indicated internally in case of dyspepsia, gonorrhea, colic, dysentery, jaundice, tympanitis and flatulence. A pill called *Sankhavati* made from conch shell is used in dyspepsia, acid urine, diarrhoea and chronic dysentery. *Sankha bhasma* is also used to treat catarrh, sore throat, cough and asthma.

Conch shells are used to prepare sticks used for various ocular problems namely, opacity of cornea, cataract, ophthalmic, keratitis, iritic and granular lids. In Siddha medicines, it is also used in all kinds of eye diseases including night blindness and colour blindness. Conch shell is also useful in treating itching of eyelids and chronic conjunctivitis with mucous discharge, especially in children. *Sankha bhasma* is also used to treat catarrh, sore throat, cough and asthma.

6. Cephalopods

The internal shell of *Sepia officinalis* is often found floating in sea water. The shell (cuttle fish bone) is an oblong, elliptical or oval, flat substance of whitish colour, porous and brittle. It is an antacid like chalk, used as astringent and a local sedative. When powdered, it is used as a dusting powder to relieve the ear pain or in otorrhoea and medicated oil prepared by boiling fine scraping of the bone in sweet or sesame oil is used as drops for same purpose. Its paste made with lime-juice is used in treating itches and other skin diseases. It is also used with rose water to control prickly heat. The powder is an ingredient of various tooth-powders. A thin paste made of cuttle-fish bone and rock salt in rose water is used to control conjunctivitis. The powder is also given internally to control sprue and dysentery.

Cowries

Cowry is the name given to small, convolute glossy shells of variegated colours of oblong, oval shape varying in size. Three varieties of cowries — white, red and yellow are used in medicine. The ash form of *Cypraea moneta* known as *Cowrie bhasma* contains phosphate, fluoride and carbonate of calcium, magnesium, phosphate and manganese. It is used in the treatment of dyspepsia, jaundice, enlarged spleen and liver, asthma and cough. It is externally used as caustic in various forms of ointments.
7. Fishes

In Ayurveda, different properties have been ascribed not only to different fishes, but also to same fish living and growing in different waters. Fish from different sources are also recommended to be taken in different seasons. The Materia Medica of Ayurveda mentions that a sea fish is heavy, unctuous and sweet. The fish and its eggs are sweet and have aphrodisiac properties. It increases stool and semen and is an excellent promoter of strength because the sea fish are mostly carnivorous. Fish liver oil derived from liver of shark, skate and sand fishes are beneficial in debilitating diseases and in malnutrition. Clarias batrachus Linn. is used in the treatment of diarrhoea. The flesh of Saccobranchus fossilis is a demulcent, a cardiac stimulant, aphrodisiac, galactagogue and also used in treating jaundice. Oil of Scomberomorus commersoni Lacep. (Seer Fish) is used as a substitute for cod liver oil. The flesh of Trichogaster fasciatus has astringent and constipating properties.

Squalus carcharius (White Shark) is found along the Indian coasts. The oil extracted from its liver is called Oleum Squalae which is extracted by boiling fresh liver in water. It is an amber coloured oily liquid with a fish odour and taste like cod liver oil but more strongly marked and more disagreeable when left for some times. It deposits a white granular substance stearin which is called Squalin. It is richer in iodine and phosphorous than cod liver oil but contains less bromine and sulphur. As an emulsion it is used daily as a nutrient, demulcent and alternative. It is given to treat cachexia, pulmonary consumption, atrophy, scrofulous affections of the joints and bones especially rickets, scrofulous ophthalmic and scrofulous abscesses, suppurating glands, ulcerations and discharges from the nose or ears and skin diseases. It is also used in treating mesenteric affections of children with tumefied belly with loose and clayey stools, in their obstinate constipations and in stricture of the rectum, chronic hydrocephalus, the advanced stages of spasmodic coughs such as whooping cough and other lung affections and cholera, epilepsy, neuralgia especially Tio Doulouroux, chronic rheumatism causing atrophy, some form of paralysis and leprosy.

Live fish

In the Indian city, Hyderabad, live fish is used as a cure for asthma. The success of this 156 year old traditional medicine is a closely-guarded secret by one family. A yellow-paste (the ingredients of which are kept secret by the family) is stuffed into the mouth of a two-to-three-inch long "murrel" fish and this is then forced down the gullet of the patient. It is claimed that the movement of the fish clears the phlegm in the patients windpipe as it makes its way down to the stomach, where the medicine is digested.

8. Turtles

Oil extracted from the turtle, Chelonia mydas is nutritious and used as an alterative and demulcent. The turtle fat is given to control scrofula, rickets, anaemia and pulmonary infections. Turtles shell is used in Siddha preparations to treat opacity of cornea, cataract, ophthalmic, keratitis, iritis, granular lids and in all kinds of eye diseases including night blindness and colour blindness.

9. Sea mammals

Sea Cow, Halicore dugong (Dugong dugon) Erxleben. The oil of the sea cow, Halicore dugong Erxleben, known as Dugong oil or oil of Sen Hog is used as a substitute for cod liver oil.
Future prospects of marine products in drug
development

The Indian Ocean is the repository of a diverse and rich source of flora and fauna that have not been explored systematically for their commercial use. The use of marine organisms in Indian medicinal systems mentioned in ancient Indian texts clearly indicates their indispensability. The calcium and carbon found in corals, shells and pearls are not in the form of calcium carbonate and hence are considered as different calcium salts which are used in a wide range of ailments. Chemistry of marine natural products is a relatively newer area of potential resource to chemists and pharmacologists for discovering new therapeutic targets or developing new leads. In the 1980s, researchers discovered that horseshoe crabs' blood could be used to detect dangerous endotoxins in drugs, medical devices and in water. Bryostatin 1, a compound isolated from the bryozoan Bugula neritina is on a Phase I trial for use as a treatment of melanoma, non-Hodgkin's lymphoma and renal cancer. Conotoxins are useful tools for examining the molecular nature of diseases in which the function of nicotinic receptors in the brain is impaired, such as Alzheimer's disease, Parkinson's disease and epilepsy.

Several sponge species e.g. Sigmosceptrella and Prianos produce compounds which have shown great promise as drugs to combat malaria, tuberculosis and other infectious diseases. Many compounds extracted from sponges have also anti-viral, anti-neoplastic and anti-cancer properties.

Halichondrin B, first isolated from the Japanese sponge Halichondria okadai, has shown potential in vivo treatment for melanoma and leukemia and is currently in preclinical trials. Debrromohymenialdisine (DBH), one of several constituents of the common Paluan shallow-water sponge Stylotella aurantium is an interesting drug like molecule that is easily synthesized and is being developed for the treatment of osteoarthritis. Marine resources are sustainable sources of various natural products hence have great potential in drug development.

Conclusion

The marine ecosystem offers a huge potential in the naturally based pharmacopoeia. However, clinical evaluation of various organisms providing natural products is to be done. Scientific approach is needed in order to transfer innovative discoveries and traditional medicine into active clinical therapeutics.

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