THE OCEAN - NATURE'S TRASH BASKET

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Sooner or later everything ends up in the ocean. A bit of exaggeration, perhaps, but nearly true. We've long thought that all of the things dissolved in sea water, from salt on down to trace elements, were leached from the land and carried into the sea by runoff. The recent discovery of venting in the ocean bottom at spreading centers, and the buildup of polymetallic sulfides in these areas modifies that a bit, and might explain why open ocean fishes have so much mercury. But that is something that marine geochemists will have to study and pass judgment on. Any way, it doesn't change my point, which is that lots of things that started somewhere else end up dissolved in sea water, or if they don't dissolve or float, settle on the ocean bottom.

Early man was attracted to the ocean, and soon learned to visit the shallow rivers near the ocean when fishes were migrating. The intertidal area was a rich hunting ground, and piles of mollusc shells attest to the role marine foods played in the diet of these early nomads.

Later on, villages were built near rivers, and some that especially flourished were situated on rivers near the sea, convenient to shipping. The rivers played another role as man became more civilized. They carried his sewage to sea. Without ocean disposal of these wastes, disease would have been even more devastating and people would have been forced to scatter to avoid the plagues. Of course, banding together in cities advanced civilization, and fostered the flowering of the arts and sciences. The Greek and Roman civilizations owed much to the magnificent sewage and water systems their engineers built. But the ocean has to be given some credit for absorbing these wastes and slowing the spread of disease.

We still rely on the ocean as a trash receptacle, just as Mother Nature apparently designed it to be, but recently it is considered anti-environment or even anti-American to put anything toxic into the ocean. And the thought of putting radioactivity in the ocean alarms millions of people.

The dumping of packaged radioactivity in the ocean is carefully limited in the London Convention, and some materials cannot be dumped at all. Other pollutants are covered by the Marine Protection, Research, and Sanctuaries Act of 1972 (P.L. 92-532), also known as the Ocean Dumping Act.

This Law was enacted to "regulate ocean dumping of all materials that would adversely affect human health, welfare, amenities, the marine environment, ecological systems, or economic potentialities." The Law was amended in 1977 to mandate that the ocean dumping of harmful sewage sludge cease by December 31, 1981. New York City was not able to comply with this order and succeeded in getting a judge to intervene, allowing sludge dumping to continue. As I write this, it appears that the Environmental Protection Agency, enforcers of the Law, will not appeal the court decision.

The Ocean Dumping Act, in addition to regulating the ocean disposal of low-level wastes, prohibits the dumping of high-level radioactive wastes in ocean waters. Low-level wastes can be dumped only when "no practical alternative offers less risk to man and his environment."

The laws themselves sound reasonable -- why dump radioactivity in the ocean if some other "alternative offers less risk to man and his environment?" The problem is that the regulatory agencies are interpreting the laws in such a way that the option of ocean disposal has become no option at all. Until the end of 1981, at least, there was movement toward a ban on ocean dumping of nearly all toxic materials.

I understand that Congress will soon hold more hearings on the subject of ocean waste disposal. The National Advisory Committee on Oceans and Atmosphere (NACOA) has, in a 1981 report entitled, "The Role of the Ocean in a Waste Management Strategy," suggested that the ocean be used for waste disposal in those cases where it was clearly superior to land. Recently, regulation has been media by media, with those guarding the oceans showing no concern for the land, and vice versa. NACOA clearly favors a multi-media approach, with the ocean receiving more consideration than it has had recently. But the NACOA report makes no mention of radioactivity. That is my topic -- why I think the ocean is clearly superior to the land as a receptacle of radioactive waste. Although I'm in favor of both high-level and low-level wastes going in the ocean (or below the ocean floor) the problem will only be discussed in a generic sense, with no details on specific techniques.

Instead, I'd like to "stand back and take a broad view," a philosophical approach. Since fate has made me the lead-off speaker on the ocean aspects of waste disposal, I can introduce you to some of the workings of the ocean that will help explain why it is so resilient, and, thus, why it is such an excellent place for the disposal of radioactive wastes.

I realize we're conditioned to think of the sea as fragile -- there's a best selling book called the The Frail Ocean, and perhaps we've seen too many Cousteau movies preaching that the hand of man is ruining the sea. And certainly the pressure of the environmental lobbies on Congress is to protect the sea. "The oceans, our last frontier -- so wild and deep and pure -- must be saved for posterity. We've ruined the land and the air, let's not foul the ocean too." That's their plea.

You've heard the arguments and, at first glance, they are convincing, and I believe public opinion goes along with the "protect our ocean" theme. I call it the "inviolate ocean syndrome," and its endemic. But noble as it sounds, and good as it feels to support such a seemingly worthy cause, I believe it's wrong. Dead wrong, because what doesn't go in the ocean must go on land, and that's the worst thing that could happen to we terrestrial animals who call ourselves "Man." We've simply got to open up the oceans for use as a waste receptacle or run the risk of poisoning ourselves.

This discussion will not dwell on the old question of whether "concentrate and contain," as the Environmental Protection Agency seems to insist, is better than "dilute and disperse." Maybe the former is better for high-level wastes and the latter is preferable for low-level wastes. At any rate, if you believe the linear hypothesis, it doesn't much matter which alternative you pursue. If you "concentrate and contain," only a few fishes (or whatever) will be irradiated, but some to high doses. Since the concentration (and dose rate per unit volume) of the radionuclide varies inversely with the volume of the water in which it's diluted while the number of fishes increases directly with the volume, the products of dose times the number of fishes irradiated are constant whether you dilute or not. At least, this was the conclusion of a committee (chaired by Dr. Donald Pritchard, State University of New York at Stony Brook) brought together by the Atomic Energy Commission (AEC) to evaluate the problems to be faced if one of the plutonium-fueled electric generators in a space vehicle fell into the ocean.

My own preference in ocean disposal is for maximum dilution for low-level radioactive wastes, which avoids the unpleasant problem of the nets of some fisherman coming up with barrels covered with AEC logo. We've had too many of those already. As far as high-level wastes are concerned, I only ask that the ocean not be excluded from consideration, because it has a number of things going for it.

Let's look at the facts.

Land area is a minority on this water planet. It makes up less than 30 percent of the planet's surface, and much of that -- the mountains, polar regions and deserts -- is not the normal abode of man. Clinging to the coastal fringes and the valleys and plains, man derives over 85 percent of his food from land, and nearly all of his fresh water. This last resource -- fresh water -- makes up less than one percent of the total water supply. Ninety-seven percent of the world's water is polluted with salt, most of which is in the oceans, and two-thirds of the other three percent is locked up in glacial ice. The remainder, this priceless treasure -- our potable water -- is most vulnerable to toxic substances disposed of on land. Yet forty million Americans depend on untreated well water for sustenance and are vulnerable to toxic materials leaking into the water table from land-based "dumps."

For many wastes, including most radionuclides, the sea is clearly a superior repository. Not only can the various processes in the ocean cleanse, dilute and detoxify the wastes, but there is almost no danger of any of them returning to man in our farm and dairy foods, or in our drinking water. Once in the ocean, most processes -- chemical, physical, geological and biological -- tend to keep them there.

But might the release or storage of wastes in the deep oceans pollute them? Not if done wisely and in moderation. My thesis is that the ocean is more capable of accepting wastes than the land. It is almost as if the ocean were designed to be Nature's trash basket. It can take pollutants -- and always has -- and, within limits, process them and detoxify them. It has a carrying capacity -- an ability to accept wastes and process them without harm to the organisms in the sea, or to man who feeds on them. We can see by the degradation of our bays and inlets that the carrying capacity of these restricted areas with poor circulation is extremely limited. But offshore and in areas where currents are powerful, both the dilution and the carrying capacity are much larger. If the carrying capacity is not exceeded, the ocean will continue to be an excellent waste receptacle without undue degradation.

There are good reasons for this. The ocean is both three dimensional and in constant movement, so most pollutants are quickly diluted and dispersed. Gravity, diffusion and advection spread pollutants throughout the water column, reducing their toxicity. Since the average depth of the ocean is 3800 meters (about two and one-third miles), there's lots of water for dilution. And because the ocean waters move and mix, they constantly renew themselves, with "fresh" surfaces presented regularly. That is, the ocean waters you bathe in along the shore today are usually not the same waters as were there yesterday. Compared with the ocean, one weakness of the land is that it does not turn over and renew itself, but constantly keeps the same dirty face presented to us. This earth's surface accumulates pollutants and tends to keep them in the top layers of soil where plants grow and animals live. Thus, terrestrial plants -- with their roots near the surface and their leaves receiving air borne pollutants -- are more exposed to pollution than marine organisms.

Many pollutants, including most radionuclides, tend to bind to the numerous particles in sea water -- clay, detritus, and even small plants and animals (plankton) -- and are carried to the bottom by gravity where they are at least temporarily isolated from man. Even chemical processes, such as precipitation by iron and manganese hydroxides, tend to remove pollutants from the water.

The ocean, contrary to the words of poets, is not pure water, but is actually quite toxic to man. It is a chemical mixture of many things, including the stable isotopes of most radionuclides that we might put in the ocean. These stable isotopes cause "isotope dilution," which results in less of the radionuclides being taken up from the water by living organisms than would occur otherwise. A classic case is strontium-90. Though fearsome in terrestrial food chains, strontium-90 is not much of a threat in marine food chains, for two reasons. There is an abundance of stable strontium in sea water, and that dilutes the strontium-90. And there is even more calcium in the ocean, which is chemically similar to strontium. Thus, an organism in the water can't accumulate much strontium-90 because the radioactive atoms are literally inundated with stable strontium and calcium atoms. There is no organism known that can concentrate strontium-90 without picking up the more abundant and innocuous stable strontium, which dilutes the strontium-90 so that it's much less toxic. Cesium-137, another bad actor on land, is diluted by stable cesium, but to a lesser degree, and chemically similar potassium -- and so it goes with most of the radioelements, with the exception of actinide elements such as plutonium. There is no stable plutonium in the ocean (or on the land) to dilute radioplutonium.

Tritium deserves a special word, since it will be a byproduct of fusion, which is being touted as the energy source of the future. Tritium, clearly, is more benign in the ocean than on land. After all, tritium is a hydrogen isotope and the ocean is mostly hydrogen and oxygen, so dilution will be nearly infinite. There is a concept in radioecology known as "specific activity," which is a numerical expression of the degree of isotope dilution that helps explain why tritium and most other radionuclides are relatively benign in the ocean. This concept states that the ratio of the radionuclide (tritium) to its stable isotopes (in this case, hydrogen and deuterium) cannot exceed the ratio of the tritium to hydrogen in the water in any organism living in the sea water. That is to say, if we added enough tritium to the ocean to make one out of every million hydrogen atoms radioactive (tritium), then no organism in the ocean can contain more than one tritium atom per million hydrogen atoms. This explains why the huge dilution ability and the abundance of trace elements in the ocean are so important in reducing the uptake of radionuclides. A rule to remember is that the specific activity concept works only when the radionuclide is in the same chemical and physical state as its stable elements -- then the radioactive atom is truly mixed and diluted with the far larger pool of stable elements.

But isn't it true that marine organisms have a tremendous ability to concentrate radionuclides -- even when greatly diluted -- back up to lethal levels? This was looked at rather carefully by a committee in a 1971 publication of the National Academy of Sciences (Radioactivity in the Marine Environment). They found the greatest concentration ability in the phytoplankton and zooplankton, but as the radioactivity moved up the food chain through euphasiids (small shrimp-like animals) and small fishes to the predators -- the salmon, tuna, etc. -- less and less radioactivity, in general, was passed upward. This is good news for man, who dines at the top of the food chain.

Here it's instructive to compare food from the ocean with food from land. In general, marine food chains are longer than their terrestrial counterparts. On land we eat either plants -- or parts of plants -- from the very bottom of the food chain, or the animals -- chickens, cows and pigs -- that feed on plants. In the ocean we don't normally eat the plants (phytoplankton) or the animals that eat the plants (zooplankton). Instead, we feed on the large predaceous fishes from the top of the food chain. Although this is a simplified picture (it overlooks oysters and clams that eat plankton, and certain smaller fishes like herring), nevertheless, most marine food chains are longer so that any pollutant that is discriminated against (and many, including most radionuclides, are) reaches your dinner plate in less abundance than if passed through a shorter terrestrial food chain.

Even so, marine food chains, though they supply less than 15 percent of the world's food, are expected to be the major pathway from the ocean back to man of any radionuclides dumped in the ocean. Other exposure pathways such as by fishing, swimming, wading, sunbathing or boating are less important, because man's contact with the sea is extremely limited compared with our intimate association with the land.

The danger from radiation to plants and animals is much less in water than in air. Water is nearly 1000 times denser than air, and quickly absorbs radiation. While a land animal living one foot from a radiation source might get dangerously high levels of radiation through the air, a marine animal living a foot from the same source underwater would get only a much lighter dose through the water. It's common knowledge that water is an excellent absorber of radiation -- we use it for that purpose in the so-called "swimming pool" reactors, as a shield. Of course, radioactive waste under the ground would be well shielded by the dirt and rock, so this comparison would only hold if the waste were removed and brought to the surface. Under water, divers could approach such a source much closer with impunity.

The ocean is already radioactive, but not so much as the land. Yet each liter of sea water contains enough potassium-40, a natural radionuclide, that it decays at the rate of over 600 disintegrations per minute. Even so potassium-40 is not the major contributor to the dose of some marine animals. Dr. Folsom of Scripps Institution of Oceanography reported a tuna liver from the open Pacific Ocean that contained enough polonium-210 (a natural alpha emitter) to have an internal dose of 79 rem per year. (The equivalent of about 1600 chest x-rays, assuming an average chest x-ray at 50 mrems.) But that was abnormally high. The more usual range for polonium-210 doses, according to Drs. Cherry and Heyraud of the International Laboratory of Marine Radioactivity in Monaco, is 90 to 240 mrem (two to five chest x-rays) for whole body dose for the marine animals, with 2.4 to 6.7 rem per year (about 50 to 135 chest x-rays) for the internal organs that accumulate polonium-210; i.e., the alimentary track and hepatopancreas. These doses, courtesy of Mother Nature, are larger than one would expect to see from low-level radioactive waste disposal in the sea.

At least those natural doses reported above are much larger than the doses seen, years later, from disposal of radioactive wastes into the sea in the past. In response to some wild cries of alarm by a California scientist (not a radiation expert, apparently) about the radioactive waste disposal site near the Farallon Islands, off San Francisco, being a threat to all of California, if not the world, a Congressman asked GAO (the U.S. General Accounting Office) to look into it. Their report, dated October 21, 1981, has such a revealing title that you don't need to read the report to see what it says, for the title is "Hazards of Past Low-Level Radioactive Waste Dumping Have Been Overemphasized."

Data inside the report show that only the University of California scientist, (who stirred up a few politicians and nearly all of the media) expressed alarm about radiation from the dump site. The thirty other scientists -- mostly experts in the field -- found no cause for alarm. In fact, the GAO report stated that "an annual human consumption rate of 45 pounds of the fish in the Environmental Protection Agency's sample (presumably "contaminated") would yield an annual dose which is approximately 1000 times lower than the dose from radionuclides occurring normally in the human body." To put that in perspective, that would be very much less than the dose from one chest x-ray. Not enough to hurt a baby, but enough to be featured on network TV.

And that will be a major problem in using the sea for radioactive waste disposal. The American people have a love affair with the ocean and a hate relationship with radiation. That's too bad, because my experience as a marine radioecologist leads me to believe that our future is best served by using more nuclear technology, which is benign compared with most alternatives, and wider use of the sea for the disposal of the resulting radioactivity.

To my mind, the ocean is designed by Nature to be self-cleansing, so it can handle radioactive wastes far better than the land, and, therefore, that is where the wastes should go. Gradually, I think, public opinion will swing in favor of using the oceans for this purpose. That seems inevitable as more and more of us crowd ourselves on this finite bit of real estate, and begin to reap the consequences of having put all of our most toxic wastes on land -- this precious land that feeds, clothes and houses us, and provides our drinking water. And I believe the politics of the situation will lead us to the oceans too. In these supercharged times, pushed and shoved by special interest groups, and influenced by a media that seems to specialize in negativism, it will be impossible for a politician to have his state play host to a nuclear waste dump site. Somebody else's state, of course, but not these hallowed grounds, never. And yet no state can afford to give up the miracles of nuclear medicine, the protection of a nuclear navy and the benefits of nuclear power. Therefore, pressures are going to build for the inevitable radioactive wastes to go elsewhere than in the territories of the fifty sovereign states. When push comes to shove, then we will turn to the ocean -- Nature's trash receptacle. It's good to know that the ocean will be ready when we are. As they say, "ready, willing and able."

But what if these vaunted cleansing processes fail to work as expected? What if the skeptics who insist on keeping the ocean inviolate are right? What if the radioactivity, despite logic to the contrary, gets back to man?

Here we're in luck, because the relevant experiments have already been done. The massive nuclear tests in the Pacific-one hundred six U.S. above ground (or in the ocean) shots alone-dropped large quantities of fallout on land and sea alike. Forty three bombs were detonated on Enewetak and twenty three on Bikini. Fortunately, since the natives removed from these two atolls were anxious to return as soon after the tests as possible, scientists have carefully studied both terrestrial and marine ecosystems there to determine the rate of recovery.

Their results lend credence to my thesis, that the ocean cleanses itself much faster than the land, for the many reasons given earlier. Thus the food chains in the lagoons and adjacent seas are low in radioactivity and have been for years, so the natives can eat local fishes in unlimited quantities. On the other hand, terrestrial food chains-coconuts, papayas, land crabs, etc.-are still too contaminated with radioactivity (mostly strontium-90 and cesium-137) to be used on a daily basis and, at the rate land plants are losing their radioactivity, it will be some time before they can become an integral part of the native diet.

It's reassuring to recommend greater use of the ocean for radwaste disposal when Nature has confirmed that the ocean is best. In fact, it would be foolish not to consider the ocean, seeing that its recuperative powers are so great.

The opinions expressed are solely those of the author.