CHAPTER 41

WATER POLLUTION: SOURCES; MONITORING; AND PREVENTION

41. 1. WATER POLLUTION

41. 1. 1. Introduction

Water is one of our most vital resources. Human beings can live for a month without food, but cannot survive more than a few days without water. Earlier we discussed some of the special properties of freshwater, brackish water, and seawater. It is these properties that make life possible on our Planet Earth.

Among its most important properties, water can dissolve nearly everything. This makes water excellent for transporting things, especially nutrients and minerals for plants and animals.

Water carries the raw materials of life from the environment into living bodies. Water transports these products internally and later removes the wastes of life processes from the bodies of all plants and animals.

This powerful dissolving property also makes it excellent as a cleaning agent. Water picks up dirt and other things and carries them away. It is this property of water that makes it so easy to pollute.

Although water covers almost three-quarters of our planet, only a very small portion of this water is fresh water. Only fresh water is available to us humans. This small amount of fresh water comes from our precipitation, from our groundwater, and from our surface waters.

On our small, relatively high Pacific islands there is usually very little, if any, surface water. In the CNMI we are almost completely dependent on groundwater. Unfortunately, much of our groundwater is lost every day due to leaks in the delivery system.

Rain is a tremendous resource of fresh water, but unfortunately it is used only to a very little extent here in our Commonwealth.

As our population has grown, our water quality has continued to degrade. This is true for the tapwater that we drink, shower, and wash with. It is just as true for our nearshore ocean waters.

Although water covers almost three-quarters of our planet, only a very small portion of this water is fresh water.

Sediment in the water occurs when soil gets into the water, which makes the water muddy and thus blocks much of the light in the water.

Six pack rings from our soft drinks often choke and strangle sea birds and sea mammals to death.

In previous chapters we learned about water sources and cycles. In this chapter we will learn how we pollute water, and how we all can, and should, prevent and control damage to one of our most vital resources.

41. 1. 2. Physical Pollution

Sediment in the water occurs when soil gets into the water. This makes the water muddy, blocking much of the light. Submerged plants need to use light to make food. If there is no light, they cannot make food and oxygen (photosynthesis). The underwater food chain is disrupted.

Sediment also smothers things that live on the ocean bottom, such as coral. (Recall our extensive discussion of this problem in our chapter on Coral Reef Problems.)

In addition to the problems caused to corals on our reefs, particles of sediment provide areas for ocean bacteria to settle. Harmful outbreaks of bacteria colonies and other diseases may occur whenever there is too much sediment.

As discussed, plastic garbage in marine waters is a serious threat to marine animals. At the time of this book's writing, trash blowing from our uncontrolled dumps are a major source of our coastal waters' debris. Careless and thoughtless people often dump their trash directly onto our shores.

Waves, wind and tides then carry this garbage into the water where it can travel long distances on ocean currents.

Some sea turtles, particularly the largest sea turtle - the Leatherback turtle (*Dermochelys coriacea*), eat jellyfish. These turtles often mistake plastic bags for jellyfish. They eat them. Then their digestion and breathing organs get clogged. Then they die.

Six pack rings from our soft drinks often choke and strangle sea birds and sea mammals to death.

41. 1. 3. Biological Pollution

Sewage and other organic wastes are a form of biological pollution. These pollutants can alter the balance of nutrients and minerals in water. Human sewage pollution is a problem in many crowded areas.

If these wastes enter our waters, the wastes from people sick with intestinal diseases can be passed to swimmers and people who eat contaminated fish and shellfish.

Fortunately, nature is very good at processing organic wastes and cleaning them up. The pollution problem occurs when there is too much in one spot. Then there may be too much for the environment to handle.

If a lot of sewage is dumped in one place, it may also cause another kind of problem. Organisms which decompose organic wastes use up oxygen. If too many wastes are put in one place, then too much oxygen is used up. Then animals, like fish and shellfish, cannot

live there. Their deaths contribute food to more decomposers, which use up more oxygen, causing even lower water oxygen levels. This is called **eutrophication**.

Effluent from our sewage treatment plants is piped directly into ocean water. At the time of this book's writing, this happens at two sites on Saipan. Tinian may soon have one or more sewage treatment plants as well. Plans for improving Rota's sewage treatment capacities for Songsong Village are on the drawing board. An innovative pond-wetland treatment plant with no outfall is now operational at the Rota Resort. (See our Wetlands Chapter). It may also serve to treat sewage soon from the Sinapalu homestead.

Effluent from our sewage treatment plants is piped directly into ocean water. Currents disperse Saipan's two outfalls' wastewater around our lagoon and nearshore waters.

Currents disperse Saipan's two outfalls' wastewater around our lagoon and near shore waters. Unfortunately treatment plants are often overloaded and in poor repair, so the discharged wastewater is often poorly treated at best. Sometimes it is not treated at all.

In 1991 Saipan discharged over a million and a half gallons of untreated sewage into the Saipan Lagoon each day. Under federal orders to do so, the facilities were upgraded and, at the time of this book's writing, the flow from our treatment systems' outfalls meet US Environmental Protection Agency water quality standards.

41. 1. 4. Chemical Pollution

Strong chemicals are used extensively here in the CNMI as cleaners, pesticides, and fertilizers. Hotels and restaurants use many cleaning agents that are poisonous to people and many organisms.

Water carrying these agents gets flushed down the drains and toilets. These chemicals are made to last a long time. They pass right through our treatment plants without being changed. They are also washed directly into marine waters by rain water.

Strong chemicals are used extensively here in the CNMI as cleaners, pesticides, and fertilizers. These chemicals pass right through our treatment plants without being changed and are also washed directly into marine waters by rain water.

Chemical cleaning formulas that are readily biodegradable are now available and should be used as a better alternative.

Fertilizers

Fertilizers that are washed into the ocean waters act as fertilizers in the sea, just as they do on land. Excess nutrients in water upsets the balance of nature. **Algae blooms** can occur because of the excess nutrients.

Too much algae chokes fish and other marine organisms and is not pleasant to swim in. Water with excess nutrients and dense algae is also a good place for bacteria to grow.

Pesticides

Pesticides are a class of chemical compounds that are powerful poisons. Pesticides are used to control insects and unwanted vegetation such as weeds. We should be aware that these chemicals kill plants and animals, and will kill us also if used too much. The most dangerous thing about pesticides is that they are made to last!

Pesticides are made to cling to our garden plants even when it is raining. They are made to keep killing bugs for months after application. They are almost always present in the food we eat, no mat-

ter how well we wash it. Should we then still wash our food anyway? Yes, definitely yes!

As we apply pesticides, month after month, year after year, they build up slowly in the soil, in our houses, and in our bodies. This is a grim reality which must be acknowleged. Otherwise, we might not change the often-unneeded and often-very harmful spray, spray, spray, habit.

Pesticides can kill marine life, just as they kill bugs and plants on land. The amount of these poisons entering our groundwater and marine water is very difficult to estimate. It is even more difficult to estimate the effect they have on the marine ecosystem.

Pesticides are a class of chemical compounds that are powerful poisons used to control insects and unwanted vegetation such as weeds.

We can be certain, however, that there is some effect. This effect is a negative one too. As with many types of pollution, it may be years before the effects of widespread pesticide use becomes apparent to us.

Cleaning Agents

Cleaning agents are another class of powerful chemical compounds. Many of these are poisonous — like pesticides, or nutrient-rich — like fertilizers. We use them with lots of water to clean up our messes, then flush them away.

Eventually these chemicals make their way into groundwater and marine water. They have many of the same effects as pesticides and fertilizers. On the other hand, there are very few, sometimes no regulations whatsoever to control their use.

Metals

The last type of chemical pollution we will discuss is metals. If we looked in a chemistry book we would find that most of the natural elements are metals. Many of these metals are used in the biological processes of life. But biological systems use them in extremely small quantities.

It is very interesting to learn that the very metals we need to stay healthy are deadly poisons in higher concentrations. The best example is iron, needed to transport oxygen in our blood (iron adheres to the heme portion of our blood's **hemoglobin**). At elevated levels however, iron causes severe mental disorders and death.

Exotic metals such as cobalt, molybdenum, and vanadium are also used in our bodies. Their concentrations are so small however, and their processes so mysterious, we do not know how they are actually used. What we do know is that even the tiniest bit extra is dangerous to most living things.

Metals are often found in organic solvents used as cleaners and in some pesticides. They are also found in wood preservatives and printing ink.

Waste oil contains metals. Nearly all types of paint contain metals in high concentrations. Photography uses several metals for film developing. Many of the items we throw in our trash contain a wide variety of metals.

Over the years these metals build up in the soil. Eventually they make their way to our coastal waters. Metals accumulate in fish and shellfish, and in us too.

41. 1. 5. Oil Pollution

Everybody contributes to oil pollution. We all contribute when we wash greasy hands and flush the water down the drain. We contribute when the oil pan on our vehicle leaks, or when we run the outboard motors on our boats.

Everybody also contributes indirectly when we use products made of oil. These products include plastics, chemical fertilizers, electricity (generated from oil fuels), gasoline, aviation fuel, and diesel fuel.

We all use these products everyday, so everybody has a share in oil pollution. If we ride in an airplane, drive a car or truck, or turn on an electric light, we contribute to oil pollution.

Oil seeps into our environment little by little, everyday, from the sources like those mentioned above. But it can also enter the water in very large quantities, all at once, from an **oil spill.** There are serious effects from an oil spill. When an oil spill occurs there is also a danger of fire.

Oil can enter the water in very large quantities, all at once, from an oil spill which poses a serious threat to the environment.

Oil is toxic to marine organisms. Since some of the oil is soluble in sea water it can travel long distances affecting animals and plants far away. Fish and filter feeders like clams and mussels are easily tainted by oil, then they are unfit for eating.

Seabirds have a major problem if they become coated with oil. Their feathers lose their insulating quality. Oil on a bird's belly and legs can be passed on to eggs or chicks. The birds may eat fish that are infected with the oil and then pass this food on to their chicks.

The coating of a shoreline with oil is a major, and often a long-term effect of an oil spill. Coastal strand and shallow water plants are often smothered by oil spills.

Creatures such as clams, worms, and other burrowing animals are smothered as well. Nature will eventually clean up even the worst oil spills, but this takes many, many years. In the meantime many populations of animals and plants die. No one can fish, swim, or otherwise enjoy the oil-polluted waters for a long time.

41. 2. WATER POLLUTION AND DEVELOPMENT IN THE MARIANA ISLANDS

41. 2. 1. Introduction

In this section we want to emphasize that any type of development can cause water pollution. Some types pollute more, some less. Water pollution is easier to prevent and control in some types of development, and harder in others.

As discussed in our earlier chapters, there are currently several types of development here in our Commonwealth. The major categories include residential, commercial, tourism, and agriculture.

Rapid development on Saipan over the last 20 years has significantly contributed to water pollution.

Each day, people use the drain or toilet to dispose of a variety of harmful chemicals. Most of these chemicals are not affected by the treatment plant and end up in the lagoon or groundwater.

Each development type results in all the different types of water pollution discussed above.

Sometimes we are not aware of the sources of water pollution because, in our modern lifestyles, we take so many things for granted.

41. 2. 2. Residential Development

More people means more water used. More water used means more water polluted. The population of our Commonwealth has soared in the past thirty-five years. This is especially true on Saipan, but Tinian and Rota are growing too. All these people need water.

A major source of water pollution is the wastewater from the houses and apartment buildings we build to accommodate our growing population. This wastewater is often called domestic wastewater, or **sewage**. It is the used, dirty water we dispose of down the sink, shower and toilet every day.

Generally, household wastewater is the “cleanest“ wastewater. If a person is careful of what they dispose of down the drain, household wastes are mostly simple organic wastes that are easily broken down by nature.

When large numbers of people dispose of their wastewater in an area, however, nature cannot keep up. The result is water polluted by high concentrations of organic compounds. These compounds act as nutrients and cause the unpleasant smells, algae blooms and disease breeding grounds discussed earlier.

One answer is to treat the sewage water before it makes its way to the sea. Wastewater treatment plants are usually very good in treating this type of waste. There is a problem though when too much water is sent to the treatment plant. When a treatment facility is overloaded most of the wastewater exiting from it is poorly treated, or not at all.

One might think the answer is to build more or larger capacity treatment facilities. Wastewater treatment plants cost millions of dollars and take many years to design, permit, and construct. When the population grows too fast, there is not enough money or time to build treatment works to keep up. This is what happened to Saipan in the late 1980’s and early 90’s.

In addition to there being too much of it, there is another concern with household wastewater. It is never as clean as it should be. This is because each day, people use the drain or toilet to dispose of a variety of harmful chemicals.

Many of these are cleaning agents used around the home. Others are paints, solvents and oils that are thoughtlessly disposed of. Most of these chemicals are not affected by the treatment plant and end up in the lagoon or groundwater.

Many houses and apartments here in our Commonwealth use septic tanks and leaching fields for wastewater disposal. When properly designed, sized, and constructed, septic systems with leach

fields can effectively treat small volumes of household wastewater. It is important to note that septic tanks need to be pumped out, on average, at least once every five years to remove accumulated sediments and other nondecomposable material. If they are built on certain soil types, this needs to occur even more often.

Improper design, maintenance, or too great of wastewater flows can cause the same water pollution problems mentioned above. Too much wastewater results in overflowing septic tanks. These cause unpleasant odors and create breeding grounds for noxious insects and diseases. Harmful chemicals can seep out of overloaded tanks and make their way to our groundwater and eventually to our lagoons and beaches.

Residential development will continue to have a major impact on water pollution here in the CNMI. This will continue as long as our populations continue to increase and we continue to use and dispose of water from our homes without thinking about what we are doing.

41. 2. 3. Commercial Development and Infrastructure

Introduction
The problems of water pollution from commercial development are also tied to population and disposal practices. As more people live on our islands, more opportunities arise for businesses.

Many of the pollution issues of our businesses are similar to those of residential development. There are additional concerns for chemical pollution and oil pollution in our highly commercialized economy.

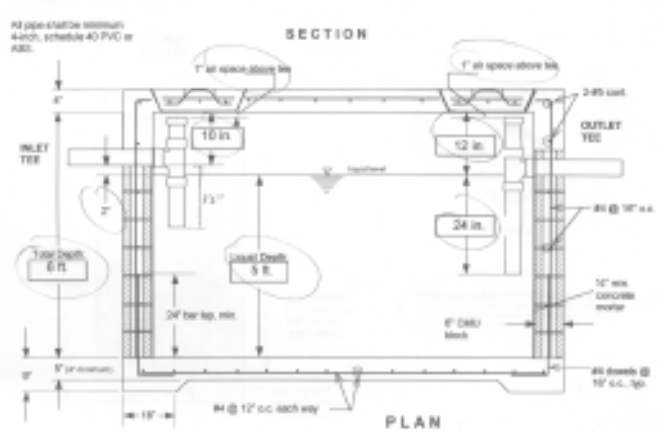
Laundries and Restaurants
Restaurants and laundries discharge large volumes of water that have high concentrations of organic wastes. They usually require a sewer hookup because they discharge more water than can be effectively processed in a septic tank and leaching field.

A single commercial laundry discharges more waste water daily than dozens of houses put together. Large restaurants do the same.

As the numbers of these businesses increase, the sewage flows to treatment plants increases dramatically. The additional sewage water exacerbates our earlier discussed problem of overloading.

These businesses often use chemical cleaning agents in large quantities. Restaurants use pesticides in large amounts as well. These chemicals make their way into the treatment plants and lagoon waters, worsening our water pollution problems.

Photography Businesses
Photography businesses are a major source of metals contamination. This contamination is in sewage sludge and treated wastewater. Film developing results in waste solutions that have a high concentration of heavy metals. These metals are unaffected by the treatment process.



Many houses and apartments here in our Commonwealth use septic tanks and leaching fields for waste water disposal. When properly designed, sized, and constructed, septic systems with leach fields can effectively treat small volumes of household wastewater.

Sludge containing metals is disposed of on land. Rain water eventually washes these metals into our groundwater and lagoon water. Metals that remain in solution are discharged directly to our marine waters.

Fuel Storage and Motor Vehicle-related Wastes

The number of vehicles in the CNMI is growing rapidly. As vehicles become more numerous, the number of businesses needed to service them increases too. These include repair garages and fuel stations.

Photography businesses are a major source of metals contamination in sewage sludge and treated wastewater.

Garages have large quantities of **waste oil** to dispose of. They also have large numbers of discarded **lead-acid batteries**. Fuel stations store large volumes of fuels.

At the time of this book's writing there is no good method for disposing of waste oil in the CNMI. It continues to build up in storage containers. It is often haphazardly disposed of in the dump, or is poured illegally into sewers or just tossed into our jungles. Leaking containers, oil in the sewers, or oil on the ground all contribute to severe water pollution problems.

Large quantities of stored fuel also pose a water pollution hazard. Eventually all storage tanks leak. As the number of our fuel storage facilities increases, the incidences of groundwater and coastal water pollution by fuel increases as well. Special double walled fuel containers and leak detection equipment are now mandated by federal law for all fuel storage facilities.

Infrastructure Concerns

Our infrastructure, which is needed to provide modern services to our fast growing populations, is also a source of water pollution which is usually not recognized by the public.

Auto repair garages have large quantities of waste oil and discarded lead-acid batteries to dispose of.

Infrastructure for our commercialized society creates its own water pollution problems. Power generation has two major water pollution sources associated with it. The first is waste oil accumulation. The second is fuel storage. Both of these sources lead to oil substances eventually making their way into our waters.

Another infrastructure-related concern is the erosion caused by building roads and parking areas. Road construction usually takes a long time. Soil is exposed to the elements for long periods, increasing the amount of sediment that is washed into our coastal waters.

Roadways also result in soils and shorelines polluted by grease and oil. Roads collect grease and oil deposited by vehicles. During dry periods these substances build up.

Rain washes the accumulated material off our roads and onto the roadsides. It then seeps into the groundwater, or is carried to the lagoon by drainage structures.

Fuel Transport and Piping

Fuel tank farms located at harbor sites are a major source of potential water pollution that few people recognize. These storage

farms have vast networks of underground piping. This piping is often exposed to seawater. Corrosion results in leaking pipes and fittings. Tanks leak too.

There are occasional spills during the off-loading of tanker supply ships. Somebody forgets to shut off a valve. Flexible and even ridged hoses break every so often. Fitting seals may not be complete. Under pressure, weak points burst open. Tanker ships themselves are often a source of pollution when they discharge bilge water that has mixed with oil.

Fuel tank farms located at harbor sites are a major source of potential water pollution that few people recognize.

41. 2. 4. Tourism

Introduction
Tourism is a special type of commercial development that has a severe impact on water quality. This may be hard to realize at first. Tourism is usually associated with economic success.

A visiting tourist, however, has a much greater impact on natural resources than a local inhabitant. This is because they live a much more resource-intensive lifestyle during their brief stay.

An endless stream of tourists means a constant population that is using electricity, wastewater services, trash services, water, and so on at a much higher rate than locals.

Unfortunately very little of the money each tourist spends stays on our islands to help pay for this higher resource use. Each visitor arrives, uses up a tremendous amount of resources, then leaves. Their brief visit affords them little time to learn about our pollution control and resource protection laws. The fact that they do not live here might also mean that they have little appreciation for the fragility and the need for us to all to take care of our environment.

Tourism is a special type of commercial development that has a severe impact on water quality. This may be hard to realize at first, as tourism is usually associated with economic success.

This is the true nature of tourism all over the world. Very few nations are willing to accept this, however, because the lure of money is so strong.

Cleaning Agents
In the CNMI, the hotels and restaurants that serve the tourist community are a major source of water pollution. In order to remain clean, bright, and hospitable for guests, hotels and restaurants use an extraordinary amount of water. Cleaning uses much of this water.

Cleaning occurs much more frequently in the tourist industry than in a private home. Think about this carefully. Do you wash your floor, your bed linen, your bathroom, and so on everyday? Probably not.

Cleaning so often uses up large quantities of water that is flushed away with large quantities of cleaning agents. Commercial laundries that provide linen service to our hotels and restaurants contribute to this also.

Pesticides, Fertilizers, and Organic Wastes
Another serious aspect of tourism is the high amounts of pesticides and fertilizers used for hotels and golf courses. Even though

we attempt to regulate their use, these chemicals are widely used in high concentrations. Eventually they make their way into our groundwater and our lagoon.

High volume, concentrated organic wastes result from large numbers of people occupying small areas. High-rise buildings are a typical example. The problem is worse when multiple high-rise structures are located together.

One serious aspect of tourism is the high amounts of pesticides and fertilizers used for hotels and golf courses. Even though we attempt to regulate their use, these chemicals are widely used in high concentrations.

The organic wastes originate mostly from toilets and from kitchen wastes. In the tourism industry, much more waste is created in preparing food than in a typical private household. Much of this waste is flushed away with water, increasing the organic load on treatment plants and lagoon waters.

Electricity Use

The tourist industry also uses large amounts of electricity. As we have seen, generating electricity is a source of oil pollution. At the time of this book's writing, when over 720,000 tourists come to the CNMI each year, there is an enormous quantity of fuel burned to keep the lights on and the air conditioners running.

It makes no difference whether a hotel or restaurant has its own generator. As we have seen, anyone who uses fuel contributes to oil pollution in our waters. Increased use of electricity eventually results in increased oil pollution.

Litter and Other Solid Wastes

Finally, tourism creates a lot of trash. This is not to say we are not responsible for our trash as well. We are! A fair amount of the litter seen on our island, however, is left by our tourists and our guest workers.

41. 2. 5. Agriculture

Modern agriculture on our islands is a major source of water pollution. Both the use of pesticides and fertilizers, and erosion from improper farming practices contribute heavily to our water pollution problems.

Large farms may also be a source of concentrated organic wastes. Chemicals, sediments, and organic wastes from our farms eventually make their way into our groundwater and marine water.

Erosion is a major concern and is discussed more in our next section. Widespread use of inorganic pesticides and fertilizers creates serious chemical pollution of our waters. Their use eventually leads to soil sterility as well.

When soils are sterile, plants can no longer grow and hold the soil together. Then the erosion problem gets worse. Farming is usually thought of as an activity that takes care of the land and water. In many uncooperative commercial examples however, it is not.

As island ecology students, we should think carefully about the unplanned, unmanaged, over-commercialization of our islands, including our farms.

You will recall from our earlier chapters that lowered costs equal higher profits. Why should our farmers participate in costly cooperative soil and water conservation programs? If using high amounts of fertilizers and pesticides helps one grow and sell more vegetables, why should our farmers control their use?

Ignore costly erosion and water pollution control measures, plow more land, use more fertilizers and pesticides, use more water, grow more crops, make more money. Seems logical but it's not. There are better farm management methods. These are sometimes called Best Management Practices or BMP's. The Soil and Water Conservation District and the Natural Resource Conservation Service are good sources of additional information.

We should all learn to weigh the costs and benefits associated with each land use proposal. Then we can make more informed decisions. Farm sustainably? Yes!! Farm via exploitive, polluting techniques? No!!

Large farms may also be a source of concentrated organic wastes. Chemicals, sediments, and organic wastes from our farms eventually make their way into our groundwater and marine water.

41. 2. 6. Erosion

Introduction
Erosion is a major source of water pollution here in the CNMI and is a common problem for all types of development. We discuss it here in a section of its own.

Erosion always occurs when the soil is unprotected from direct rainfall, or from water running over its surface. When there are no plants to hold the soil, the sun dries it and the wind blows it away, or water washes it away. Soil is exposed when forests are cut down, when the land is bulldozed to build something, and when vegetation is burnt.

For our islands we can categorize our erosion processes into two basic types. One type is coastline erosion. The other type is inland erosion.

Erosion is a major source of water pollution here in the CNMI and is a common problem for all types of development.

Coastline Erosion
Rain, currents and wave action continually shape and modify our coastline. These forces wash away soil or sand and deposits them in another place. Wind is also an effective agent in the movement of soils and sands. Wind-driven waves are always contributing to our coastline erosion. Over a period of time, waves can undermine even the strongest shore. Storm waves can even move large rocks and boulders.

Our coral reefs protect our coastlines from intense wave action. Each reef acts as a buffer. Our reef-protected coasts are generally not subject to the most damaging of wave actions. Erosion of our leeward coast proceeds at a slow rate because of our reefs.

However, periods of exceptionally heavy wave action during storms can result in much accelerated coastal erosion. People can also accelerate erosion processes on coastlines. This is often done by disturbing natural protective agents such as the destruction of coral reefs or the removal of strand vegetation.

As sand is lost, roots of shrubs, herbs and trees become exposed.

Over a period of time, waves can undermine even the strongest shore.

As we look at our erosion problems, perhaps beach erosion is the most obvious. Churning seas and frequent storms may significantly alter our beaches. Storm action can down shoreline trees. It can move tons of sand as well.

It is obvious that natural factors are significant in coastline erosion. However, several human activities likewise contribute to our beach erosion problems. Sand mining for construction activities contributes to erosion. The removal of vegetation near the shore is also important in this aspect.

As sand is lost, roots of shrubs, herbs and trees become exposed. This exposure can kill the natural vegetation. Vegetation is important in holding down erosion because the roots of plants bind and keep these soils in place. It is now obvious that both the removal of sand or the removal of vegetation produce the same results.

Another human activity that threatens some beaches is the illegal use of dynamite on coral reefs. Dynamite destruction exposes areas to the direct force of large waves and currents. These areas, once protected by the natural buffer of the reef, become exposed.

Lastly, poorly designed coastal protection structures can accelerate erosion events as well. Revetments, groins, rip rap, and seawalls are all examples of engineering solutions to shoreline erosion. If they are done improperly however, or are done without historic geologic data, each is doomed to fail. Each will just cause more problems elsewhere along our coasts.

Examples of such problems abound across the Pacific region. Such projects should only be allowed if they are adequately funded and are designed and supervised by professional coastal engineers and geologists.

Inland Erosion

Inland erosion is normally a slower process than that of coastline erosion. However, inland erosion can be greatly accelerated. Residential development can strip the land of protective vegetation. Once cleared, rainfall washes the exposed topsoil away. Thus, several forces are again at work producing erosion. Gravity is pulling materials from higher to lower regions. At the same time water serves as the transport medium. Other human activities may speed up inland erosion in the same way if they are not properly conducted.

Eroded inland soils ultimately wash over our land. These soils then move out into the sea. When this happens it has a serious effect on coastal marine habitats. This process of moving sediments into coastal waters is known as **siltation**. Siltation is a major water pollution problem associated with development of all kinds. Siltation can be harmful in two ways:

First, the water becomes very cloudy (**turbid**) and murky. Sunlight is then filtered out quickly. This can have adverse effects on corals, marine plants, and other invertebrates which require sunlight.

Second, as the sediment settles from the water onto the sea bottom, it can build up and bury bottom-dwelling (**benthic**) organisms, particularly our sensitive corals.

Minimizing Erosion
Pollution and development in our islands are closely linked. We are just like every other densely populated nation that uses a lot of technology. Just as in the cases of our air and solid waste pollution, in the case of our water pollution, everyday we essentially live in our own waste.

As students of island ecology we must weigh the benefits and sacrifices associated with our technology and our commercial economy. What do we get as their benefit? What do we sacrifice as payment for them? Must we?

Sustainable farming is, after all, many thousands of years old. It is time to reacquaint ourselves with it.

Regulating and applying proper construction methods for roads, parking areas and buildings are ways we can minimize erosion. During construction, soils are exposed for long periods. We already know that heavy rains here in our islands cause severe erosion unless special care is taken at construction sites.

Erosion is a major concern. For this reason the United States Government has produced many excellent publications on preventing it. There are so many different methods that they are too numerous to list here. Visit your local library and the offices of the USDA Natural Resource Conservation Service to find where these books can be found.

Eroded inland soils ultimately wash over our land and then move out into the sea.

41. 3. MONITORING OUR MARINE WATERS TO DETECT POLLUTION

The Division of Environmental Quality, the Commonwealth Utilities Corporation, and their cooperating agencies have several water sampling and monitoring programs. Both government agencies revise these programs occasionally to address changing water quality issues here in the CNMI. The Coastal Resources Management Program, the Division of Fish and Wildlife, and our Northern Marianas College cooperate with DEQ and CUC through the Interagency Marine Monitoring Team.

The populations of Saipan, Tinian and Rota are growing. Now more attention must be given to managing our waters. If we do not check our water to detect pollution, there could be many outbreaks of diseases.

Monitoring our water also helps us identify sources of pollution. We can then take specific steps to stop, or minimize pollution if we know their sources.

41. 3. 1. Our Drinking Water; Groundwater; and Coastal Waters' Testing Regimes

Introduction
Our drinking water, groundwater and coastal waters are each tested regularly for **microbiology** and **chemistry**. Microbiological analysis helps determine if disease-causing organisms are present in our water.

When cloudy (turbid) and murky water is introduced to the sea, sunlight is then filtered out quickly. This can have adverse effects on corals, marine plants, and other invertebrates which require sunlight.

Monitoring our water also helps us identify sources of pollution. If we know the sources, we can then take specific steps to stop or minimize pollution from them.

Our drinking water, groundwater and coastal waters are each tested regularly for microbiology and chemistry. Microbiological analysis helps determine if disease-causing organisms are present in our water.

Remember that water is the source of life. Bacteria, viruses, and thousands of other tiny invisible creatures live in the water. Many of these organisms are harmful to us and other animals.

Normally, the balance of nature keeps their numbers small. The chance of ingesting one is small too, but pollution can result in huge populations of harmful organisms. When this happens we are much more likely to get sick from drinking or swimming in contaminated water.

Chemical analysis of the water helps us determine how healthy the water environment is for the things that live in it. As we have just discussed, we humans often pollute our own water. We pollute the water of other creatures too.

If we think about the food webs we learned about in our earlier chapters, we will recognize that we depend more on other creatures than they do on us, (i.e., most don't eat us on a regular basis). It is in our own best interest to keep our waters clean and the living world healthy.

With our several hundred wells, our numerous unsewered and sewered developments, and our numerous hazardous waste sites, we have already upset the natural cycle of most groundwater on our islands. Saipan's aquifers are at greatest risk. Tinian and Rota likewise have serious groundwater concerns.

So now we must use electricity and machinery to treat this groundwater source for our use. Drinking water bottling companies treat this water with *reverse osmosis units*, then each sells this groundwater back to us as bottled water. At the time of this book's writing, each of these water bottling companies is tested weekly. These tests see if any disease-causing organisms are present in their machinery, piping, or storage tanks.

Groundwater wells are also tested regularly. These tests see if bacteria is present in the well's piping systems.

Ocean water is tested as well. If bacteria is present in high concentrations, it is probably an indication that human activity is causing the pollution of our marine environment. Be sure to check the signs at the beach before going swimming.

Similarly, if the chemistry of the water is very different than the natural state, human pollution is probably the cause.

Fecal Coliform
This is a test for bacteria that indicates the possible presence of disease-causing organisms. It is used to protect human health from waterborne infectious diseases associated with using contaminated water.

pH
This is a test to determine how acidic the water is. High levels of acids can harm many aquatic life forms. Most living things can tolerate only a very slight change in acidity.

Turbidity
This is a measure of the cloudiness of water. It is caused by suspended matter, such as clay and silt.

Excessive turbidity levels kill coral reefs. Coral reefs die from loss of sunlight. Turbidity also reduces the availability of fish food and impedes fish migration. Excessive levels prevent development of fish eggs, cause a decreasing of the resistance of fish to disease and inhibit coral spawning.

Salinity
Salinity is a measure of the saltiness of the water. High levels or low levels can cause serious problems in the development of many aquatic life forms.

Most marine organisms cannot tolerate too much or too little salinity. Ocean water has the correct salt balance for them, about 3.5% or 35 parts per thousand (35 ppt).

Dissolved Oxygen
This is a measure of the oxygen content dissolved in water. The amount of dissolved oxygen indicates the ability of water to support desirable marine life. Too little results in huge populations of odor-causing bacteria.

Temperature
Thermal pollution creates conditions which can inhibit a balanced aquatic ecosystem. As with salinity and pH, most marine animals must live within a certain temperature range.

If bacteria is present in high concentrations in ocean water, it is probably a sign that human activity is causing the pollution of our marine environment.

41. 3. 2. Recently-added Monitoring Parameters

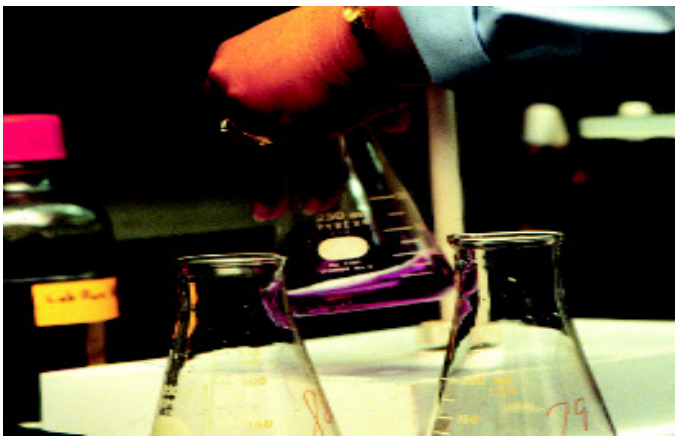
Recently, the Division of Environmental Quality and the Coastal Resources Management Program, in association with the CNMI's Interagency Marine Monitoring Team, have added new items to their monitoring programs. These include:

Coastal Waters Bacteria
At the time of this book's writing, two additional bacterial forms, *Clostridium perfringens* and *Enterococcus sp.* are being studied. Scientists want to determine their potential use as better indicators of coastal water quality.

Nutrients
Nitrate and phosphate water chemistry samples are being collected at selected beach sites. Nutrient levels can change as a result of stormwater runoff from land areas where organic pollution sources are present. You will recall that impacts from an excess of nutrients were discussed earlier.

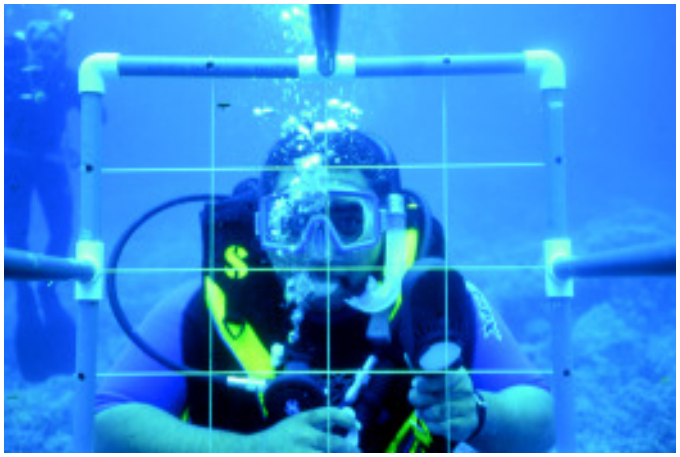
Sediments
Recently suspended sediment collectors were installed at 21 sites in coastal waters around Saipan. Two sites off Tinian also have sediment collectors.

These suspended sediment collectors are used to detect changes in sediment levels around our coral reefs. Higher sediment levels can damage or kill our coral reef communities.



CNMI water is tested for Fecal Coliform, pH, Turbidity, Salinity, Dissolved Oxygen and Temperature.

Suspended sediment collectors are used to detect changes in sediment levels around our coral reefs. Higher sediment levels can damage or kill our coral reef communities.



The CNMI's interagency marine monitoring team uses several additional biological monitoring methods to analyze coral reef health.

Constant Temperature
For a period, automated underwater temperature recorders were installed off Unai Bapot, Saipan. Temperature recorders were also placed in the Tanapag Harbor. These recorders monitored daily and annual subsurface sea temperatures.

This information was gathered to help test a hypothesis of temperature rise as a factor of occasionally-observed "bleached" coral events.

Biological Monitoring
For a time, the settlement patterns of coral larva and other larval invertebrates at several sites were being monitored using flat Plexiglas plate, ceramic tile, and other collectors. This was done around the island of Saipan.

Settlement in turbid, sediment-rich waters was hypothesized to be different than in clear waters. The coral larva settlement study served as an early biological indicator of water quality, and tested the ability of our reef community to maintain itself.

At the time of this book's writing, the CNMI's Interagency Marine Monitoring Team uses several additional biological monitoring methods. For example, the team monitors butterfly fish behavior as discussed in Chapter 15; Coral Reef Problems. The team also estimates coral cover and counts densities of crown of thorns starfish. For a time, motile marine invertebrate settlement arrays were deployed and monitored in part, to assess crown of thorns starfish densities.

41. 4. PREVENTING WATER POLLUTION

41. 4. 1. Conservation is Key

Introduction
There are so many ways to prevent water pollution that an entire book could be written on this subject alone. In fact, many have been! Visit your library and see.

Most of the methods depend on limiting water use and changing the way we use it. Much also depends on how many people are using a water source.

If there are too many people, even the best conservation efforts will fail. As students of island ecology we should think about our water sources. Consider how many people are using them.

We will give a brief account here of some major ways to help prevent water pollution. Keep in mind that large numbers of individuals working together to solve this problem will make a difference. However, in order for large numbers to work together, each individual must do their part.

Use Less; Pollute Less
Practicing conservation is the best way to limit pollution of all kinds. It is especially important for water pollution. The special properties of water make it easy to pollute. We have also seen that many of the things we do affect water quality. The activity might not have

to directly involve water. A *conservationist lifestyle* in general has many benefits, and cleaner water is one of them.

Use less and pollute less. If we use less water there will be less water going to the treatment plant, or to the leaching field. Also, there will be less water to carry chemicals and oils into our lagoons and groundwater.

Use Less Chemicals
We should use fewer chemicals in our daily lives. Most of the great variety of cleaning agents are unnecessary. Just a few will do. The rest is just advertising hype (and a waste of money). We should manage our household wastewater as if what we put in to it will come back to us. It will, remember the water cycle!

Leaks in our water pipes need to be repaired properly. Temporary control measures can lead to significant water loss.

41. 4. 2. Limit Erosion

Planting vegetation on our beaches is one of the best ways to solve this problem. Besides holding the soil in place, vegetation acts as a vehicle barrier. Remember that driving on the beaches destroys the vegetation. Driving on beaches thus accelerates shoreline erosion.

As land is farmed and cultivated, soil is tilled and therefore susceptible to erosion processes. Good farming practices control the loss of topsoil.

Five main factors make a difference in how much soil is washed away by heavy rain;

1) the texture and permeability of the soil;
2) how long and steep the land is;
3) the kind of plants growing on the land;
4) the method of filling, planting, cultivating and harvesting; and
5) rainfall intensity and frequency.

There are many areas of the world that have been farmed for thousands of years without loss of soil. There are many good books on the subject of sustainable farming. Agricultural extension agents at the Northern Marianas College, workers at the Division of Plant Industry, and those at the Natural Resources Conservation Service each have good, helpful information as well.

As land is farmed and cultivated, soil is tilled and therefore susceptible to erosion processes. Good farming practices control the loss of topsoil.

41. 4. 3. Contain Dangerous Chemicals

We will limit our discussion here to those hazardous substances described earlier. We will look at fuels and oils, pesticides, and metals.

Many populated areas have hundreds and thousands of dangerous chemicals to deal with in their waters. Fortunately we have only a few types. Even so, these are difficult for us to control.

Fuels should be the easiest of all hazardous substances to control. It is a commodity that does not build up. We use it up constantly. The trick is to contain them properly, always with a double containment backup system, with detectors in case of leaks and spills.

A problem arises when tanks, piping and transfer equipment are poorly maintained, or improperly used. Then, spills and leaks occur.

Designing, building and maintaining equipment properly to prevent fuel spills and leaks is very expensive. Like all companies, fuel companies seek to earn a profit. So they tend to spend as little as possible on costly protection measures. (Remember from our earlier chapters that cost minimization equals profit maximization?)

Contain fuels properly, always with a double containment backup system, with detectors in case of leaks and spills.

From the viewpoint of several agencies within the US Government, experience had shown that, as a group, petroleum companies generally had to be forced by law and threat of fines to "do the right thing".

The US has enacted Federal regulations and passed other strict laws with stringent requirements for the storage and handling of fuels.

From each oil company's perspective, these costs were high. Each felt, however, that these laws created a level economic playing field. Good operators who had already protected our environment were not penalized. Bad operators were. All leaking storage tanks had to be replaced. Double containment systems and the installing of leak detection systems for new facilities were required.

Economically, their cost of installation could easily be passed along to their oil products' consumers as part of their marginal cost of doing business. Today, all petroleum product suppliers within the United States must conform with these same federal standards. (See our chapter on Federal and International Laws).

When tanks, piping and transfer equipment are poorly maintained, or improperly used, spills and leaks can occur.

Waste oil is a difficult problem. Unlike fuel, it does build up. There is only so much that can be done with it on a small island. At this time it is important to store it safely, but you should know this is only a minor effort in an enormous problem.

As an ecology student, ask yourself what would it be like if you could not take your waste oil off-island. There is a very good chance that this will be the case in the future.

Pesticides, like fuels, are stored in large quantities and then used. They are highly poisonous when concentrated. Most pesticides are sold in concentrated form. Enclosures should be secured so that only people who are trained and properly equipped to use them will have access.

Above all, pesticides must be kept dry. They usually have some reactivity with water. Explosions may occur if large quantities are mixed with small volumes of water. Running water eventually makes it to our aquifers or to our coasts. Like so many other things that pollute, the best solution is to use less of them.

Eliminating trace metal contamination of our environment is a big problem. It has never been solved. There are so many sources in our technological society that the only completely effective solution would be to eliminate technology.

It is, of course, highly unlikely we as a society would agree to this. The next most effective option would be to reduce their use. This means reducing the use of products that result in metals pollution in our waters.

41. 5. CONCLUSION

In this chapter we have defined several types of water pollution. We have also described where this pollution comes from, and some of the effects each type has.

The most difficult section to discuss, and to accept, is **prevention**. The answer to water pollution prevention is an easy one to state. It is a difficult one to accomplish.

We use technological gadgets that create waste and pollution. Since water is the medium of life, many water contaminants eventually end up within living organisms.

Sometimes pollution is direct and sometimes indirect. Sometimes its effects are easy to see, sometimes not. Sometimes the products we use pollute our own water, and sometimes they had already polluted someone else's water far away when and where they were manufactured.

We cannot hide from the fact that our *lifestyles* are polluting. We can try to clean our messes as best we can, but some messes are just uncleanable.

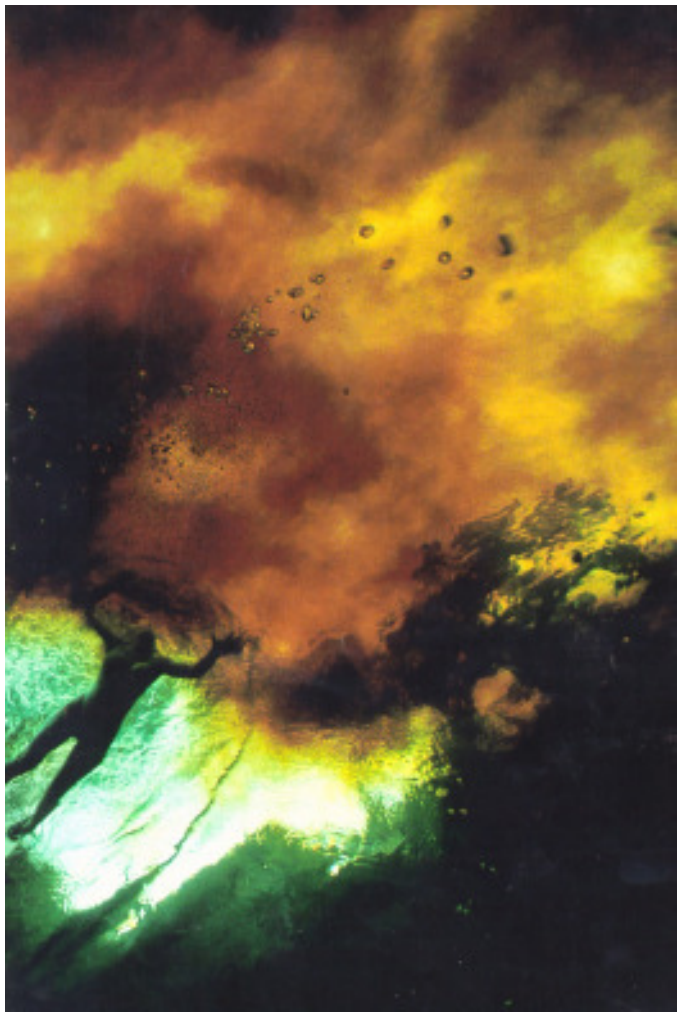
The decision that our grandparents, our parents, and now, like it or not, we've made and act on everyday, is to live in a polluted world. We choose this each time we drive our cars, turn on a light, flush chemicals down the toilet, wash our clothes, or buy a soda and throw the plastic cup or aluminum can away.

The fact is, a truly staggering amount of information has been gathered about water pollution, its causes and effects. Preventive measures are referred to in terms of treatment and technology. Yet few people seem to talk about *change in lifestyle* as a preventive measure.

Lifestyle change means using fewer manufactured goods, weeding one's garden by hand, recycling our aluminum cans, walking on our errands, having one vehicle per family, catching rainwater, erecting a solar or wind power generator. The list goes on.

With the tremendous increase in world population and the proliferation of manufacture goods, lifestyle change is very slowly emerging as the only option available to us for controlling water pollution. Whether we like it or not.

Waste oil is a difficult problem. Unlike fuel, it does build up. There is only so much that can be done with it on a small island. At this time it is important to store it safely, but you should know this is only a minor effort in an enormous problem.



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