

An Oracle from the Sand

Preventing desertization, a warning from the “booming” sand

Looking at a picture of a hot, parched desert, you might not think of nature as being much of a friend to humans.

But in fact, an important message is being sent to us by a desert when it starts expanding into green areas.

And when booming sand becomes quiet, we are being given still another message.

Both are silent warnings from the desert.

Causes and cures for “desertization”
Water in the desert
that flows up

What comes to mind when someone suggests trying to make a desert green? A lush blanket of green covering the entire Sahara Desert, complete with clear, running streams and birds chirping? This image, though beautiful, would be a misinterpretation of the vision being promoted by agriculture expert Dr. Makio Kamichika. Rather than wanting to convert existing deserts into green recreation areas, he is concerned about stopping non-arid regions from becoming deserts.

In western Japan there is a certain university whose grounds are actually a modern botanical garden. Sure enough, after entering the main gate of Tottori University Arid Land Research Center, we had only to drive a short distance before a complete artificial forest could be seen on the right. Then, just beyond it, a huge arid dome came into view, the sun reflecting off its glass reminding us how mild the weather was for February. Newly completed in 1998, the domed facility contains an artificially controlled environment that is 15 meters high by 36 meters in diameter—about one fifth the size of Tokyo Dome (home of the Yomiuri Giants baseball team and one of the largest indoor arenas in Japan). Researchers use the arid dome to perform environmental simulations that

help them learn how to prevent land from becoming arid as well as to better utilize existing arid regions. Temperature, humidity, soil content and other characteristics of deserts from around the world can be simulated.

In the reception room of the main building, which has a lovely view of the arid dome out the window, Dr. Kamichika shared with us some fascinating stories. The first tale was about the nearby Tottori dune, which he says is not really dune.

No matter where you go on the planet, there is moisture continually evaporating from the earth’s surface and from plants. But if you have enough rainfall to compensate for this lost moisture, as we do in Japan, the region will not become arid.

We can determine whether a region is arid or not by looking at the ratio of evaporated moisture to the total of precipitation plus other incoming water. Provided a minimum threshold amount of incoming moisture exists, evaporated moisture can be estimated using meteorological observation data for temperature, humidity, wind speed and sunlight. We call the amount of moisture evaporation, PET. If we call the precipitation and other incoming water P, and then divide P by PET, the resulting ratio could fall into one of these three categories: extremely arid (desert), arid, and half-arid. (See table 1.) These three categories account for 37.3 percent of the world’s land mass.

In Japan, the P/PET ratio is approximately 1.0, so the Tottori Dune actu-

ally does not exist in an arid region. The environment of Japan, as well as Southeast Asia, is not considered arid, which makes such dunes unique to the planet. From a meteorological point of view, of course, deserts are not so rare.

Originally, deserts were formed through the circulation of air in the atmosphere. If the air has insufficient moisture, or doesn’t cool enough, it won’t rain, which is why deserts have formed in various regions of the world. Dr. Kamichika is not promoting trying to change extremely arid regions—which were created according to the laws of nature—into green areas. His “green” campaign targets the arid regions surrounding deserts as well as half-arid regions. The latter is capable of supporting green trees (perhaps better than Tokyo).

Arid and half-arid regions are more compatible with human life than pure deserts. But if we aren’t careful with the way we treat the environment, and plant life deteriorates, the natural balance can be destroyed and cause an area to gradually turn into a desert. We call this process desertization.

Are desert areas increasing in size due to global warming?

That could be part of the reason. It hasn’t been proven yet, although people are actively studying the connection. The main culprit, though, is the destruction of indigenous forests to create farmland or pastureland. This not only reduces the amount of green land on the planet, it causes sand to leave the desert and move into other areas. Ultimately, some re-



gions could be turned into desert. The first task at hand is to reclaim areas that have become desert, a kind of land rehabilitation. After that we would like to learn how to grow agricultural products in arid regions to help alleviate global food shortages.

I've heard that just supplying water to a dry region is not always such a good idea.

Obviously, increasing the water supply will boost agricultural production—at first. But ultimately it can hurt the land. In arid regions, water migrates from deep in the ground up to the surface, and then evaporates. So if you supply large amounts of water to such a region, it soaks into the earth but eventually comes back up to the surface. When it does, it brings with it various salts found in the earth and in underground water reservoirs. When the water evaporates, the salts remain and the land becomes a salt desert. If we end up creating a salt desert, it's impossible to reverse the process. So if rehabilitation isn't carried out properly, things can get worse rather than better, like with a sports injury.

Our goal is long-term development. Plants grow because the soil provides them with water and nutrients. If a plant dries up and dies, its organic material puts nutrients back into the soil, which improves the water retention. Our job is to support this natural recycling process.



Dr. Makio Kamichika

Professor at Tottori University Arid Land Research Center. Born in 1941, his early research was at Kyushu university, followed by work at the Miyazaki Agricultural Experiment Station. In 1973 he joined Tottori University as an associate professor at the Sand Dune Research Institute as annex of the Faculty of Agriculture. In 1990 the Institute changed its name to Arid Land Research Center. His current research in agricultural meteorology includes arid region environmental development and natural energy resource utilization.

Making use of arid regions A cold, wet mug of beer

One basic question still remains: where can we obtain the massive quantities of water needed to prevent desertization? According to Mr. Kamichika, it can come right out of thin air.

We have this idea for harnessing the humidity generated by plants. It works like this: The plants are kept in a greenhouse, yielding moist air which is then piped underground where it cools. As it cools, the humidity in the air condenses into water, which is then collected and used for agriculture. In our experiments so far, even with mediocre equipment and poor seals, we were able to reclaim 30 percent of the water in the humidity of the air.

The next phase of this experiment focused on the role of the atmosphere. Every continent contains deserts, many on the western coasts; one example is the Namibia Desert in western Africa. Even though there are nearby cold ocean currents and cold air descending from the upper atmospheres above the sea, this region is warmed so much by the

■ Table1 Categories of Dry Areas (Taken from 1992 UNEP (United Nations Environmental Plan))

PET = the amount of water evaporating from the ground and plants (assuming there exists a minimum threshold level of precipitation or incoming water)

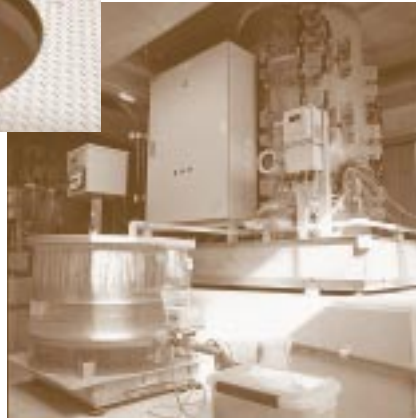
P = measured rainfall

- | | |
|------------------------|--------------------------------------------------------|
| • Extremely arid areas | $P/PET < 0.05$ (7.5% of the world's land mass) |
| • Arid areas | $0.05 < P/PET < 0.20$ (12.1% of the world's land mass) |
| • Half-arid areas | $0.20 < P/PET < 0.50$ (17.7% of the world's land mass) |

Inside the arid dome, temperature and humidity can be controlled to perform rain experiments. Nearby are several related facilities and beyond the forest, which acts as a windbreak, are the Tottori Dune.



This monitoring system tracks salt migration through the earth. The upper picture shows above the surface of the earth and the lower is underground. Sensors for monitoring salt concentration, humidity and temperature are placed at various depths to investigate how water and salt move through the earth.



land that the rainfall is virtually zero. The humidity, however, is quite high and results in a heavy mist. Some insects there are said to use their entire body surface for converting humidity into useable water.

We could produce plenty of water if we chilled the air using sea water piped from cold currents, or from the sea depths. This idea has been studied by Japan's Science and Technology Agency and works on the same principle that causes water to form on the outside of a cold beer mug.

Beyond the various projects that exist for making desert regions less arid, some Japanese companies are sponsoring research on how to better utilize our deserts.

Arid regions get plenty of sunlight, and at one point in the middle of the Sahara, they get a record 97% sunshine during the year. (In Japan, the record is 54%, recorded in Matsumoto near the site of the Nagano Winter Olympics.) This makes the Sahara ideal for solar power. Since arid areas are located all around the world, there will always be some area in sunshine. If we were to establish a global network of solar power stations in some key locations, we could send electricity to each other, all over the world, at any time of the day or night. While Dr. Kamichika is very aware of such possibilities, he speaks of them with a caveat.

Every year for the last decade, I have visited the Mongolia Moose Desert in China. These trips have given me a rich understanding of the lifestyle, culture and customs that have existed there for thousands of years. For instance, though

nomadic grazing isn't done much anymore, they used to know the capacity of a field by instinct, and would avoid overgrazing. Our efforts would fail if we tried to simply impose economically motivated views onto their lifestyle. I strongly believe that when we consider global problems such as overpopulation, we need to respect other customs and cultures.

I asked Dr. Kamichika where he was from, thinking it would be near the Tottori Dune.

I was born in China. But I don't remember it too well as I only lived there till I was four. Still, why can I remember how red the sun is at sunset, as clearly as if I were seeing it in a slide show? I feel a sense of nostalgia whenever I go to China.

The mysterious "booming" sand Strange sounds in the desert

My house is a weird place, explained Dr. Shigeo Miwa as he welcomed me inside. I wanted to deny it, but my eyes were greeted by so many strange sights, all I could do was smile.

Located in Uji, south of Kyoto, the first floor of his house was notable for its varied collection of stone mortars. On the second floor were documents and books about topics such as booming sand, the history of food and other unusual subjects. There was also a mish-mash of strange objects, including a huge sandglass, a frog sculpture and much more. It was overwhelming. A

recognized authority on booming sand, Dr. Miwa is known to travel anywhere he hears the sand is crying.

To hear booming sand in Mongolia, I once traveled by wild camel. I had to hold tightly onto its back to avoid falling, which would be very dangerous as there are places you can get sucked down into the sand. As it turns out, the wild camel is the only reliable guide around these sand traps. Once on a trip in Australia, I sat in the passenger seat of a rickety Cessna airplane, and just as it seemed like the door was about to fly open, the pilot told me to take on the job of copilot!

As evidenced by Mongolia, one doesn't need to go to the seashore to experience the booming sand, which is mainly quartz grains of 100 microns to 1 mm in diameter. If you step on it on the seashore, it sometimes sounds like birds singing. In the desert, we not only hear sounds caused by stepping on it, we can hear sounds initiated by winds blowing sand down a slope. I was told that these latter sounds, from which booming sand gets its name, can be heard up to 20 kilometers away.

In the ancient Chinese history book Dunhuang, an 880 AD entry states, "If a man or a horse steps on booming sand in midsummer, it sounds like thunder and can be heard over 100 kilometers away." Charles Darwin, the father of evolution theory, wrote in a diary from voyages on his ship Beagle that he found booming sand in several areas, including Rio Di Janeiro and Chile.

Once I was in the Badainjaran Desert in China. As 14 of us were descending a 50-meter-high sand dune, there was a huge roar with loudness of around 60-70 dB. The boom from the sand sounded so much like a propeller plane passing overhead, we automatically looked up at the sky. I don't know why, but hearing that sound made everyone's thoughts turn toward spiritual matters. On another night we were having a party around a campfire, listening to a Mongolian girl sing. Suddenly we heard the sound of booming sand, the kind initiated by the

wind. We'd been wanting to hear that sound for so long...it's like dreaming . Perhaps Dr. Miwa was expecting my next question, because suddenly he said, beforehand, let me tell you, I do not wish to look for an answer as to why the sand cries. As I have said many times before, 'Do you ask why a bird sings?' Why the sand has stopped crying is a far more important question than why it cries. I think this requires a little more explanation...

Booming sand as a gauge for environmental pollution
Deserts—the silent shoreline

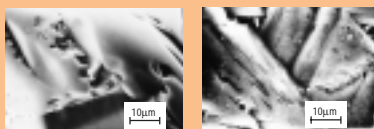
In 1962, the American science journalist Rachel Carson wrote "Silent Spring," a landmark book warning of the dangers of chemical pollutants such as DDT. The beginning of the book paints a scene where nature has suddenly become quiet. The silence brings up in her an odd and discomfoting feeling, and an obvious question: where have all the birds gone?

At first, the message of her book was criticized because it was interpreted as being more concerned with insects and birds than feeding human beings. In spite of this, plus the fact she had been diagnosed with cancer, she worked to promote her message to the world. Gradually, people began to understand the importance of preserving our environment, and today the relevance of her views are much clearer.

Just like the birds in "Silent Spring," the booming sand is now quiet. The cause is pollution. Though we can't see it with the naked eye, dirt has adhered itself to the booming sand causing it to be silent. (This dirt is comprised of extremely minute particles. See photograph 1.) What produces this dirt? The causes include agricultural runoff, untreated sewage and household waters dumped into the ocean and waste water from construction projects. In the desert, dirt now also comes from tourism.

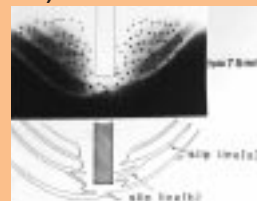
Today, if we don't step really hard on the booming sand, it remains silent. This is due to pollution. If the sand were pure, you could make sounds with little effort.

■ **Photograph 1**
Booming sand and the pollution
(microscopic view)



The booming sand on the left is capable of sound production. The sand on the right has been polluted with adhered dirt to the point it is unable to cry anymore.

■ **Photograph 2**
The mechanism of booming sand
(X-ray photo)



When you insert a stick, only the booming sand exhibits coherent pressure waves. Thought to be caused by high intergranular friction, such waves are periodic and form along slip lines. This interface layer is what allows an entire section of sand to suddenly slip, en masse, the unique phenomenon which makes the sand cry.

In modern Japan, it's becoming hard to find any sand at all, even polluted sand. I've heard reports from all around the world that the booming sand is silent, even in regions mentioned in the Chinese history book Dunhuang. I recently heard a report that the Sahara Desert has the same problem.

No one questions why birds sing. But if pollutants cause birds to stop singing, we would certainly ask why. As with booming sand, we need to know the reason for silence—a far more important question, as Dr. Miwa pointed out. Though I agree with him, in an effort to better understand the meaning of pollution, I would like to look at the mechanism by which booming sand makes its sound.

Uncontaminated booming sand has a very high coefficient of friction. And just like a crowded train in Tokyo, its individual grains are packed together so densely it is difficult to drive a stick into it, much more so than normal sand. Booming sand initially resists your efforts at inserting a stick because of strong static friction that exists between particles. But if you push hard enough, static bonds break along an interface, over which a section of sand will begin to slide. (see photograph 2.) It's like a fault line, where a large group of particles suddenly slip en masse.

Once the static bonds have been broken, the friction becomes dynamic friction, which is much weaker. That's why after you finally get the stick moving, it's much easier to push. The moment you stop, however, the friction between sand grains becomes static again and the resistance is much stronger.

Repetition of this process causes the fault line to vibrate, and this is what produces the sound. It's never the result of friction between individual particles or between particles and the air.

When pollutants such as oil and dirt adhere to the surface of the sand, friction between particles is reduced and they slide more easily. As a result, the mechanism for producing sound no longer functions and the booming sand loses its voice.

One thing I noticed in the clean Badainjaran Desert (China) I mentioned earlier was that our jeep didn't create sand flurries behind it like we often see in movies or on TV. That's because the flurries we see on TV and in the movies are actually caused by dirt, not sand. When I looked at booming sand under the microscope, I discovered that it actually glitters. In its natural condition this sand is undeniably beautiful.

If only slightly contaminated, booming sand can be washed to restore its sound. On the first floor of his home, Dr. Miwa showed me his homemade sand washer, which utilized a milling machine. By spinning sand and water inside a 10-liter polyethylene container at about 60 RPMs for anywhere from 100 to 1,000 hours, he washes sand in much the same way nature does as waves crash onto the shore. It also led us to recognize another technique used by nature.

If you 'rub' water with quartz, which is the main ingredient in booming sand, you get amorphous silica (silicon). It's slightly soluble in sea water, which already contains some dissolved silicon because of this. The 'rubbing' washes the surface of the quartz, and if the water is cold enough, the amorphous silica can become solid, like glass. It's this process that smoothes the quartz particles so they glitter so beautifully. And their composition is similar to today's high-tech semiconductors.

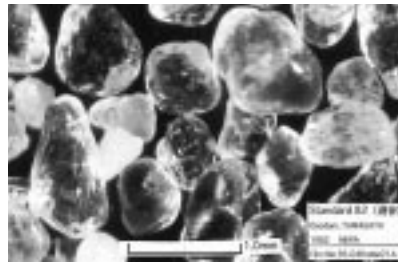
Then why does the booming sand of the desert glitter as well?

There are always lakes located near

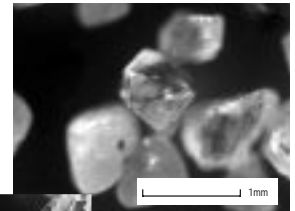


Dr. Shigeo Miwa

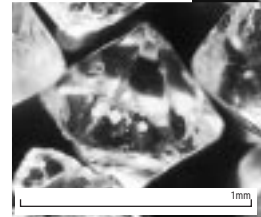
Professor Emeritus, Doshisha University, Kyoto. Born in 1927 in Gifu Prefecture, he majored in Materials Science, Powdered Technology. His early research focused on sifting techniques, while later work was with stone mortar and booming sand. Currently an advisor for the booming sand network of the Japan National Trust for Cultural and Natural Heritage Conservation, he has traveled throughout Japan and the world to investigate booming sand. He is also interested in developing ways of using stone mortar to make tofu, which he studied in China.



Booming sand from Osodani, Yamagata Prefecture. When mixed with water in a large container and shaken, clean booming sand will produce a distinctive sound.



High-temperature quartz particles found in booming sand from Kotohikihama, Kyoto Prefecture.



booming sand, and these lakes put some extra moisture into the air. The increased humidity is part of what nature needs to make the glittery amorphous silica. Lakes and deserts, a combination beautiful beyond imagination.

Dr. Miwa suggested I shake a container of sand that was still in the process of being washed. (The sand was from Osodani, Japan. See side column.) As I shook it, I felt a definite shift immediately followed by a gurgling sound that was much louder than I had expected. Just as Dr. Miwa had predicted, it sounded like a frog singing.

Over three million years ago modern-day humans did not exist on this earth. The sound you just heard is what small animals would have heard when they were at the seashore.

At Tottori's sandy beach, which are famous for booming sand, we tried diligently to step on it properly—but could hear nothing. Maybe the conditions that day were not so good, or we were unlucky. Definitely, Dr. Miwa would not like us to regard the sand's silence as casually as we did.



Dr. Miwa's discoveries on Kakumihama at Makimachi, Niigata Prefecture and at Iidemachi, Yamagata Prefecture support the theory that booming sand exists along a single straight line extending through Asia.

A mysterious line

As indicated on this map, Japan's booming sand is found along a single straight line, a phenomenon studied by scholars since the 1960s. Initially, Dr. Miwa was not a strong backer of the theory, though he later made a key discovery in support of it.

I heard about some beautiful white sand located inland in Osodani, Iidemachi, Nishiokitama County in Yamagata Prefecture (bordering the Japan Sea some 500 kilometers north of Tokyo). I obtained a sample from a friend, and after washing the sand, it cried beautifully. It comes from land that, 3-5 million years ago, was underwater somewhere in the Japan Sea. Because of this, we think it's probably the same as the booming sand that existed back then on the Japan Sea coast. The same kind of booming sand can be found all along a sand line that extends down through Taiwan, Vietnam and Thailand.

Dr. Miwa's home page (<http://www.wao.or.jp/smiwa/>) contains extensive information on booming sand, including sound recordings.