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Environmental Monitoring of Industrial Waste using Remote Sensing

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S u m m a r y

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The biggest illegal dumping site in Japan has been found on the border between Iwate and Aomori Prefectures. It has caused major social problems such as environmental contamination and is a cause of anxiety among local inhabitants. Improvements in the environmental conditions such as the removal of the large amount of waste and an improvement in water quality are urgently needed and, therefore, the development of a system for observing the state of contamination and the state of recovery on the site and an environment assessment and analysis of the results are also needed. For this purpose, a remote sensing system consisting of satellites and on-site sensors have been established for this study and the data collected by the system and other data are to be combined for environmental analysis in order to forecast and prevent the escalation of contamination and thus the damage caused by negative publicity, and observe the state of recovery.

After the system of on-line sensors was established, observations on water, observations through cameras installed on the site and observations of the weather were made. Data from NASA's Terra and Aqua satellites were received directly by our university and analysed. As a result, a relationship between the changes in the temperature of the surface of the ground on the site and the existence of industrial wastes was successfully confirmed. In addition, situations in which the natural features of the site had changed were confirmed using SPOT images.

I n t r o d u c t i o n

The biggest illegal dumping site in Japan has been found on the border between Iwate and Aomori Prefectures. It has caused major social problems such as

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environmental contamination and is a cause of anxiety among local inhabitants.

Fig. 1 is an aerial photograph showing the state of the illegal dumping site in the past. The size of the site is 16 hectares in Iwate Prefecture and 11 hectares in Aomori Prefecture. However, the total amount of waste dumped in Aomori Prefecture was 670,000 m^3, more than four times the amount dumped in Iwate Prefecture, 150,000 m^3. The upper side of the area shown in Fig. 1 is a precipice.

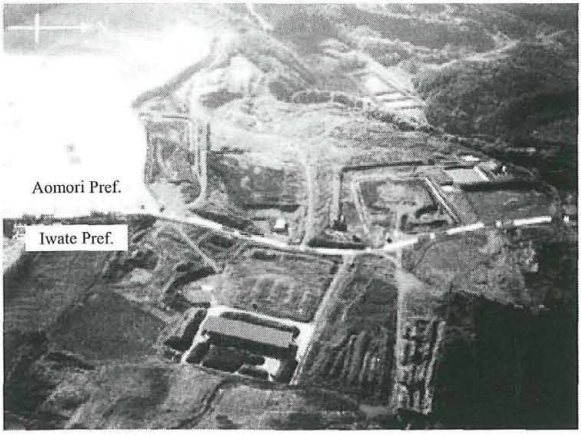


Fig. 1. Aerial photograph of illegal dumping site.

Below the precipice, there was a lagoon (which does not exist now). In the past, water from the site collected in this lagoon and the water of the lagoon was reddish brown and gave off an unpleasant smell. The dumped waste is mainly sludge, incomplete RDF (Refuse Derived Fuel), and incinerated ash, etc. A small amount of medical waste is also included. On the site, toxic substances such as VOCs (Volatile Organic Compounds) and dioxins have been detected. Improvements in the environmental conditions and water quality are urgently needed (Aomori Prefecture has established a temporary water purifying plant and decided to remove all waste on the site). Furthermore, the development of an observation and analysis system for the state of contamination and recovery of conditions on the site is also needed. Data on the water quality and weather play an important role in observation and analysis of the state of contamination on the site. We have constructed an observation system composed of a satellite data reception system and on-site sensors, and carried out environmental observations at this illegal dumping site of industrial waste using it. For this purpose, a remote sensing system composed of a satellite data reception system and on-site sensors have been constructed for this study and the data collected by this system and other data are combined for environmental analysis in order to forecast and prevent the escalation of contamination and thus the damage caused by negative publicity, and observe the state of recovery.

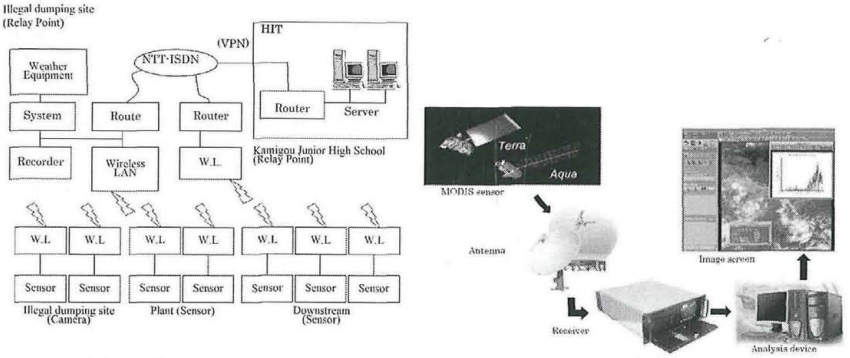
Material and Methods

On-site sensors

The observation system using on-site sensors is shown in Fig. 2(a). Data from various sensors is transmitted to a relay point through a wireless LAN. Data is then transmitted to a university located approximately 70 km away from the site through the NTT telephone network (ISDN).

Remote sensing system using satellites

The use of observation data by satellites is helpful when observing and surveying a wide area. Fig. 2(b) shows the system for reception, processing and analysis of the data from satellites installed in our university. NASA's Terra-1 (EOS-AM) and Aqua (EOS-TM) EOS satellites carry MODIS (Moderate Resolution Imaging Spectrometer) sensors, which have 36 channels of various wavelengths and a maximum resolution of 250 m. Indeed, it is not suitable with the resolution of MODIS if geographical features within the dumping site are observed, but to analyse environmental information such as temperature and vegetation, MODIS has proved to be effective. These satellites orbit the globe at a distance of approximately 700 km with a cycle of 100 minutes (RUNNING & al. 1994). Data is received directly by an antenna with a diameter of 2.4 m installed on the roof of a building on our campus. Data is transmitted from the antenna to a receiving and processing computer and automatically processed for analysis and storage. The images and values obtained by analysis can be displayed on Teravision software (SeaSpace Corporation). The ENVI software (Research Systems Inc.) is used for data analysis of details and data integration. Data from the SPOT satellite, which has a higher spatial resolution (10 m) is combined with this data for analysis (VERBYLA & RICHARDSON 1996).



(a) On-site observation system

(b) Reception and analysis system of satellite date

Fig. 2. Observation system.

Results and Discussion

The on-site sensor monitoring image screen for transmitted data is shown in Fig. 3. The items measured are pH, electric conductivity, temperature, flow rate, wind direction, wind velocity, air temperature, and precipitation. Data is transmitted to the monitoring computer in the university every three minutes. Water quality analysers have been installed at the former water supply source (Point 1), the new water supply source (Point 2), in the vicinity of the former lagoon (Point 4 and

Point 5) and in the vicinity of the Kumaharagawa river (Point 3), which is away from the site. Weather measuring equipment has been set up at the dumping site. Five relay points are located in the vicinity of the site and of the former site of Kamigou Junior High School. The infrared cameras can be operated remotely and observations can also be made at night. Environmental changes such as natural features and water quality due to the works currently being carried out on the site can be checked using this data.

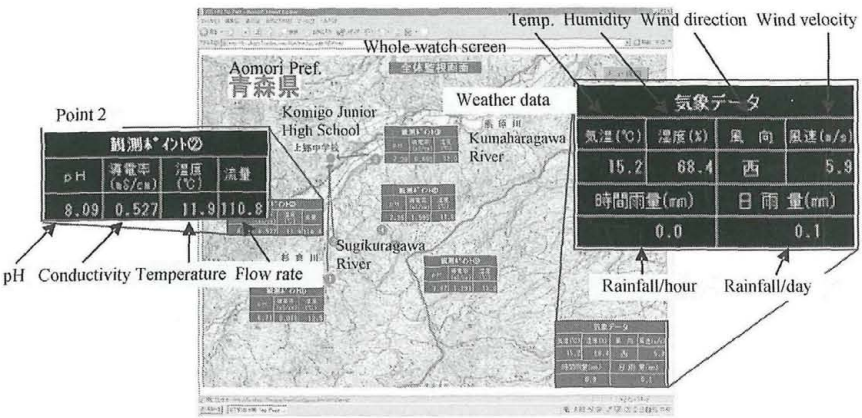


Fig. 3. Surveillance screen.

The result of the analysis of the temperature is shown in Fig. 4. The data was obtained by Terra-1 on June 3, 2004. From the spectral analysis results, it was confirmed that the peaks in Ch. 2 and Ch. 5 were bigger than those of surrounding areas (LILLESAND & KIEFER 2000). These channels receive a wavelength range near to the infrared region. This means the temperature of the ground surface may

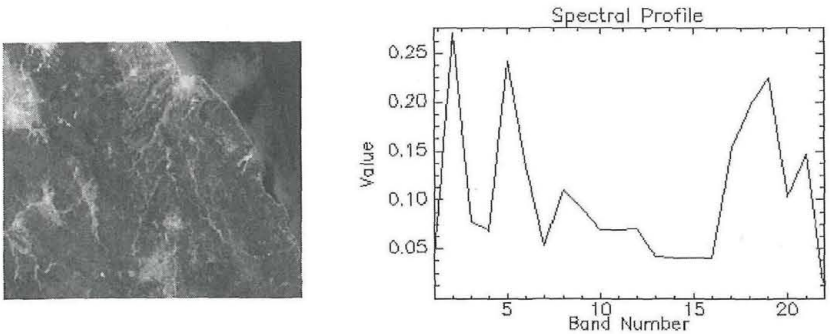


Fig. 4. Analysis results using satellite date.

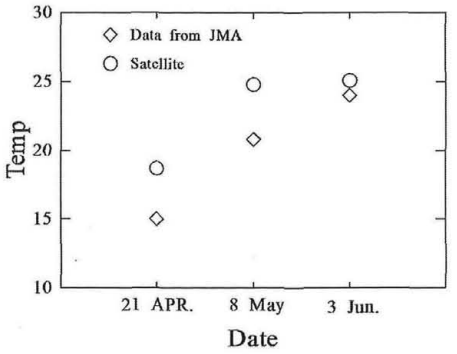
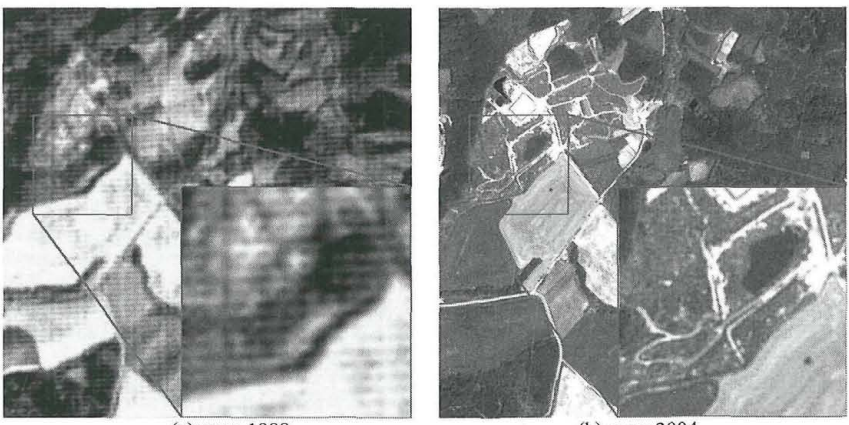


Fig. 5. Temperature data from satellite and JMA (Japan Metrological Agency, Data for Sannohe Town).

be higher to some extent than surrounding areas. Fig. 5 shows data on the temperature of the ground surface measured by the satellite data and measurements of the atmospheric temperature by the Japan Meteorological Agency. The measured values by the Japan Meteorological Agency used here are those for Sannohe Town, which is the nearest observation point to the site. Sannohe Town is approximately 20 km away from the dumping site. In general, it can be said that the temperature at the site may be lower than the observation point in Sannohe Town because the dumping site is located in a mountainous area. On the other hand, however, it can be observed that the temperature of the ground surface measured by the satellite is higher than Sannohe Town. It is surmised that the cause of the high ground temperature at the site is because waste such as sludge ferments or chemical reactions occur underground.



(a) year: 1988 (b) year: 2004

Fig. 6. SPOT images of illegal dumping site.

Images of the site taken by the SPOT satellite are shown in Fig. 6. In the image for 1988 (Fig. 6(a)), a mountain stream is clearly confirmed. In contrast, in the image for 2004 (Fig. 6(b)), it is filled with waste and the points where a capping process has been carried out in which the waste is covered by special sheets can be observed.

Conclusions

We have constructed an observation system composed of a satellite data reception system and on-site sensors, and carried out environmental observations at an illegal dumping site of industrial waste using it.

In this study, we have investigated the relationship between the results of actual atmospheric temperature measurements and the temperature of the ground surface measured by MODIS and confirmed the presence of a trend. In addition, cases in which natural features at the site had changed were successfully checked using images taken by SPOT. These results suggest that we can measure the temperature at sites of interest continuously. At the dumping site, it is difficult for us to observe environmental conditions continuously, so this will become a very powerful tool for observation.

In the future, we plan to shed light on changes in environmental conditions and the mechanisms of those changes using data from satellites, and water quality and weather data, ground truth data (data measured on-site), data on natural features, and similar data obtained from on-site sensors. At present, we are reviewing the consistency of the data in the cases where data from different sources has been combined. This will make it possible to forecast changes in the environment of the area and check on the state of recovery of the environment. Whether the removal of waste from a site has any influence on the environment of the area can also be checked.

References

LILLESAND T. M. & KIEFER R. W. 2000. Remote sensing and image interpretation, fourth edition. - John Wiley & Sons, Inc.

RUNNING S. W., JUSTICE C. O., SALOMONSON V., HALL D., BARKER J., KAUFMAN Y. J., STRAHLER A. H., HUETE A. R., MULLER J.-P., VANDERBILT V., WAN Z.-M., TEILLET P. & CARNEGGIE D. 1994. Terrestrial remote sensing science and algorithms planned for EOS/MODIS. – Int. J. Remote Sensing, Special Issue on Creating Global database 15 (17): 3587-3620.

VERBYLA D. L. & RICHARDSON C. A. 1996. Remote sensing clearcut areas within a forested watershed: comparing SPOT HRV Pancromatic, SPOT HRV multispectral, and Landsat Thematic Mapper data. – Journal of Soil and Water Conservation 51 (5): 423-427.