Report for 2005GU55B: Anthropogenic Impact on nitrogen cycle in Tumon Bay using 15N, and 14 N isotopic ratio method.

Publications

- Water Resources Research Institute Reports:
    - Author (Vuki, Maika; Denton, Gary, Wood, Rick, Emmanuel, Jacqueline; Limtiaco, John); 2006, Anthropogenic impact on Nitrogen cycle in Tumon Bay using the Nitrogen 15 isotope studies. WERI, University of Guam, Mangilao, Guam, USA (in preparation)

Report Follows

PROJECT SYNOPSIS REPORT

Project Title: Anthropogenic Impact on nitrogen cycle in Tumon Bay using ^{15}N and ^{14}N stable isotope method.

Problem and Research Objectives

Tumon Bay, on the western shore of northern Guam, is the major tourist hub on Guam. Approximately one million tourists visit Guam every year and most of them spend their time at Tumon Bay. More than 25 hotels are located in this area together with a vast array of shopping outlets, restaurants, and recreational facilities. Maintaining the natural beauty of Tumon Bay is, therefore, tantamount to maintaining a healthy economy and has become a top priority in recent years. In the middle of 2004 a major road works was completed on the Southern end of the main road and a new shopping mall will soon be built along the cliff edge beside John F Kennedy High School. These new developments will contribute to the already heavy impact of nutrients and other less desirable elements in the estuarine along the bay. The presence of stands of green alga along the shoreline of Tumon Bay is already obvious and is a major concern. The alga, *Enteromorpha clathrata*, is not a recent invader. It occurs naturally on Guam although it's increased presence and abundance in Tumon Bay appears to have paralleled the commercial developments that have occurred in the area over the last 30 years.

Another possible contributing factor to nutrient enrichment is the discharge of ground water from the northern lens aquifer through springs and seeps along the northern part of the island. There are more than ten major springs and numerous small seeps that flow into Tumon Bay. These groundwater springs are naturally enriched with nitrate – the nutrient traditionally believed to be responsible for the algal problem in Tumon Bay (Fitzgerald 1976). However, there is no clear evidence due to the increasing population of *E. clathrata* in the recent years. The alternative explanation based on phosphorus as the nutrient of primary concern also requires more data due to the increasing use of fertilizer in this area. Under natural conditions phosphorus levels in Guam's groundwater are probably low enough to limit algal growth in the Bay for much of the year. However, with the advent of bayside hotels and concomitant increases in landscaping activities, phosphorus enrichment associated with excessive fertilizer applications is suspected to have occurred in this area.

A study conducted by Denton in 2000 on Tumon bay show significant levels of nitrates in the spring water, enough to sustain algal growth. However, phosphorus levels were very low that could have significant limiting effect on the estuarine. The study also showed the rapid decline in the phosphorus level levels towards the open sea, which was reported to be due biological and chemical processes. However, there is no clear evidence from the data on the contributing factor to the increasing algal growth.

A major limitation on previous nutrient studies on Tumon bay (and in Guam waters, in general) is the ability to establish the source of pollution. For example, the source of nitrogen that contributes to the increased growth *E. clathrata* is speculated to be due to

increased development along the bay but there is still limited evidence. Knowing the source of the nitrogen or nitrates would provide a better understanding of addressing the problem. One approach of establishing the source of nitrogen will be to conduct an isotopic ratio ($^{15}N/^{14}N$). Nitrogen has two stable isotopes in the environment, ^{14}N and ^{15}N. The dynamics of the nitrogen cycle in the environment gives a very stable ratio between the two isotopes. Anthropogenic sources of nitrogen have a very distinctive ^{15}N delta values. Previous studies have shown that the isotopic ratio of nitrogen could provide a clear distinction between nitrogen sources from human and animal waste compared to inorganic sources such as fertilizer. By analyzing the isotopic ratio and the different form of nitrogen in the various components in the environment (water, plants, fish) could provide a signature for the movement of nitrogen in the nutrient cycle. Such measurement could be made in an area like Tumon bay to establish the links to possible sources and the mechanism of nitrogen transfer in the ecosystem

The aims of this study are

1. To determine the different forms of nitrogen compounds in the water system on Tumon Bay. This will involve determining the levels of nitrates, nitrites and ammonia in all the possible inputs including those that has been studied
2. To determine the isotopic ratio of stable nitrogen isotopes, ^{15}N and ^{14}N at the different components of the nitrogen cycle (water, plants, fish, invertebrates) in order to discriminate the contribution of human or animal waste nitrogen from fertilizer and industrial nitrogen
3. To determine the mechanism of nitrogen uptake through the different levels of the nitrogen cycle based on the data collected.
4. To compare the findings with previous data on the levels of nitrogen containing nutrients

Methodology

Samples were collected from the Tumon Bay and treated for chemical analysis. There were 10 sites selected. Water samples for nutrient studies were filtered and analysed using an FIA the nutrient analyser at the WERI laboratory. This was carried out to determine the levels of nitrates, nitrites, phosphate, and ammonia in the water samples. Another set of water samples were collected and treated with sulfuric acid and stored at cool temperature before shipment for stable isotope analysis. In addition to the water samples, some plants, alga, and sediment were also collected and dried for stable isotope analysis. All the stable isotope analyses were carried out at the Coastal Science Laboratory at Austin Texas.

Principal Findings and Significance

Results from this study will provide stakeholders such as major hotels, tourist tour operators and tourists on the actual sources of nitrogen in the environment. At least the contribution from human and animal waste as opposed to fertilizer could be differentiated. This will allow hotel operators and municipal authority to know the impact

of specific activities along the bay area, e.g. fertilizer application, sewage discharge, etc. It could help minimize the algal growth that is a growing concern along the bay.
The study will enhance the analytical capability of the WERI laboratory. This method has a great potential to compliment some of the existing data that lack conclusive evidence of nitrogen source or sources. It would also provide excellent training for undergraduate and graduates students at the University of Guam on analytical and environmental studies.
Preliminary analysis of data appears to show that the nitrogen from the spring waters and estuarine waters have similar delta ^{15}N values. The higher delta ^{15}N values could also imply that the major nitrogen sources could be organic.
Two undergraduate students were also trained in chemical analysis and research methodology during this project. One of them has been accepted to pursue his PhD at graduate school in the US.