2005 Annual Report for the City of Arcata

Nitrogen and Hydrogen Sulfide Analysis within the Wastewater Treatment Facility

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January 2006

INTRODUCTION

Wastewater treatment plants reduce solids and nutrient loadings discharged into receiving waters. A problem commonly associated with poor quality wastewater effluent is nutrient enrichment, or eutrophication of receiving waters (Barnes 1983). Eutrophication can cause algal blooms that deplete dissolved oxygen levels and inhibit the oxidation of ammonia to nitrate (nitrification) (Barnes 1983). The compound effects of low dissolved oxygen and increased concentrations of toxic ammonia compounds negatively impact aquatic life (Barnes 1983).

The city of Arcata, California utilizes facultative wastewater oxidation ponds to treat its wastewater. Facultative ponds consist of an aerobic upper layer and an anaerobic bottom layer (California State University, Sacramento 1994). The presence of both aerobic and anaerobic environments allows for effective nutrient removal (Horan 1990). As wastewater flows into oxidation ponds, heavy solids settle to the bottom where they are stabilized by microorganisms in the anaerobic zone (Water Environment Federation 1996). Oxygen levels in the aerobic zone are maintained by algae, which release oxygen as a by-product of photosynthesis. Since biological aeration is powered by solar energy rather than mechanical energy, wastewater oxidation ponds are generally more energy efficient than other methods of wastewater treatment. However, treatment in oxidation pond systems is usually slow, requiring detention times lasting weeks instead of hours (Horan 1990). Longer detention times also means that oxidation ponds require more land than other treatment systems (Horan 1990).

Humboldt State University and the city of Arcata have cooperated to monitor the amount of ammonia nitrogen (hereafter “ammonia), nitrite nitrogen (hereafter “nitrite”), nitrate nitrogen (hereafter “nitrate”), total Kjeldahl nitrogen (TKN) and sulfide levels at

various points throughout the treatment system. The purpose of this document is to report the results collected for the year of 2005.

MATERIALS AND METHODS

Sample Collection and Storage

Samples were collected at 14 (Site numbers are as follows: 1, 2, 3, 4, 5, 6, 7, 8, 10, 10DC, 12, 14, 15, and 15B) different locations throughout the Arcata Wastewater Treatment System (See Appendix A for map of sample site locations). Samples were collected using a sampling pole with a one-liter container attached to the end. Collected samples were transferred from the sampling pole container into individual containers designated for each site. Temperature and pH were collected in the field using a Hanna portable pH/Temperature handheld meter. The meter was rinsed with distilled water between readings to prevent sample contamination. The meter was calibrated in the laboratory prior to any sample collection using a two-point calibration procedure with pH buffers 4 and 7. Containers filled with sample were placed in a cooler with an icepack until they could be transported back to the lab. Sample analysis was typically conducted immediately upon arrival to the lab. When immediate analysis was not possible, samples were refrigerated until they could be analyzed. Sample analysis was always conducted within 24 hours of sample collection.

Sample Analysis

Total Kjeldahl nitrogen and nitrite analysis were conducted one time each month. Nitrate, ammonia and sulfide analysis were conducted on a weekly basis. All samples were analyzed using a Hach DR/890 Colorimeter. Procedures and reagents used for analysis of each nutrient can be found in Appendix B.

RESULTS

Results for ammonia, nitrate, sulfide, nitrite and TKN analysis are represented by the graphs in the following pages. The first graph for each analysis depicts average yearly values among sites to demonstrate the relative removal effectiveness for each nutrient from site to site. Subsequent graphs represent all the data collected for the entire year for each site. To reduce confusion and congestion of data points, results from the 14 sites were plotted in four line graphs instead of one. The relative scale for each nutrient analyzed are the same to provide a more accurate depiction of removal rates throughout the treatment system. Additionally, all of the raw data is provided in Appendix C.

DISCUSSION

Average ammonia levels generally decrease with increasing treatment (detention times). A possible explanation is under aerobic conditions ammonia is converted to nitrite by the bacterium *Nitrosomonas*. High levels of ammonia in the influent are expected because little biological treatment occurs in the collection system. Similarly, ammonia levels in the primary effluent are not expected to be drastically less because primary treatment is concerned more with sedimentation than with biological treatment. Ammonia levels were much lower in the months of June through mid-October than when compared to late October through late May. This may be attributed to slower nitrifications rates due to cooler temperature and less available sunlight for algal photosynthesis. Algae produce less oxygen when sunlight availability decreases. In the absence of sunlight, algae stop photosynthesizing and begin consuming oxygen. Nitrification is an aerobic process that requires 4.6 mg/L of oxygen to convert 1 mg/L of ammonia to nitrite (Water Pollution Control Federation 1983). Lower oxygen production during the winter months may have led to less complete nitrification.

During the months of May through August, nitrate levels at sites 4 through 12 experienced a noticeable nitrate spike. As mentioned previously, this may be attributed to more complete nitrification occurring due to the warmer temperatures and increased amount of sunlight. Yearly average nitrate levels do not vary as noticeably from site to site when compared to the ammonia data. This could be because little denitrification is occurring through the treatment system. As opposed to nitrification, denitrification is the conversion of nitrate to nitrogen gas under anaerobic conditions. The facultative nature of the oxidation pond may allow for some denitrification to occur, which is evident by the decrease of nitrate concentrations with increasing treatment (longer detention time).

Sulfide found in wastewater usually results from anaerobic decomposition of sulfur compounds (American Society of Civil Engineers 1989). Sulfur compounds are usually exposed to anaerobic conditions in collection systems that are failing, or do not have sufficient velocity (American Society of Civil Engineers 1989). Yearly average sulfide levels were highest in the influent, suggesting that these components may be exposed to anaerobic conditions in Arcata's collection system. Sulfide values seemed not to be affected by season, but rather by location in the treatment train. Sites 12, 14 and 15 (final treatment marshes) had the lowest yearly averages when compared to other sites. This could be caused by the immobilization and incorporation of sulfide components into cellular organic compounds of marsh vegetation (American Society of Civil Engineers 1989).

The first step of nitrification involves the conversion of ammonia to nitrite by the bacterium *Nitrosomonas* under aerobic conditions. Nitrite is an unstable compound that is quickly converted to nitrate by the bacterium *Nitrobacter*. The instability of nitrite explains why concentrations are much lower than both ammonia and nitrate. Site 3 is the only site that experienced a noticeable nitrite spike. This may be because this is the initial stage of biological treatment, where the high levels of ammonia from the primary effluent are first undergoing nitrification.

Total Kjeldahl nitrogen (TKN) is the amount of organic nitrogen plus the ammonia nitrogen (Halling-Sorensen 1993). Sites 4 through 12 experience declining

TKN values during the months of April through October before increasing. This may be attributed to the lower concentrations of ammonia nitrogen due to increased nitrification during the summer months. Sites 1 and 2, which represent the influent and primary effluent have the highest yearly TKN averages. This is probably because of the higher concentrations of ammonia at these sites. Yearly averages between the rest of the sites deceases slightly with increasing treatment (longer detention time), but do not vary significantly (see standard deviations and means Appendix C).

CONCLUSION

An advantage to a facultative wastewater oxidation pond is that the aerobic and anaerobic zones allow for effective nutrient cycling (Horan 1990). The aerobic zones allow for nitrification to occur, while the anaerobic zones enable denitrification. A well-nitrified effluent is important in protecting aquatic life by reducing concentrations of toxic ammonia and preventing oxygen depletion. The data collected over the past year indicates that decreasing nutrient levels are decreasing in a predictable fashion (impacts of increased sunlight and warmer temperatures on nitrification). Additionally, measuring sulfide levels provides information on the quality of the collection system, and can be used to determine if anaerobic or anoxic conditions are developing anywhere in the treatment train.

LITERATURE CITED

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