AALSO
San Francisco Bay Area 2013

2013 AALSO Symposium, San Francisco Bay Area, CA

Instructions to Authors

GENERAL FORMAT: Manuscripts should be typed using MS Word or similar software (no PDF please). Preferable font is Times New Roman (TNR), font size 12 (except as noted below). Set "Language" to "English (US)" and **adjust paper size to 8.5 x 11 inches.**

At the top of the first page, format as follows: **RIGHT & LEFT MARGINS:** 1.2 inches (3.05 cm). **TOP & BOTTOM MARGINS:** 1.0 inch (2.54 cm). **ALIGNMENT:** Justified (so paragraphs are block left & right). **WIDOW/ORPHAN:** On. **HEADER & FOOTER:** 0.5 inch (1.27 cm) each.

TITLE: Type the title (boldface and centered) on the second line from the top, capitalizing Major Words (TNR **bold**, font size 14); use more than one line if necessary. The title should be brief, descriptive, and have all words spelled out. If more than one line is necessary, use single spacing between lines.

AUTHOR(S) NAME(S) AND ADDRESS(ES): Skip one line. Type the author(s) name(s) centered and single spaced (TNR ALL CAPS, font size 12) with a semicolon between authors. Skip one line, then follow with the author(s) address(es), also single spaced, capitalizing the first letter of all major words (TNR *italic*, font size 12). In the case of authors from different institutions, identify the authors and appropriate institutions by corresponding Arabic numerals in superscript. PLEASE INDICATE THE SPEAKER BY UNDERLINING THAT AUTHOR'S NAME.

ABSTRACT: Skip two lines, center, type the word **Abstract** (TNR **bold**, font size 12). Skip a line and type the abstract; single spaced with one line between paragraphs. The abstract should be approximately 100 to 300 words in length. It should be concise, factual and contain the main results and conclusions of the paper, and be suitable for reproduction.

Skip two lines, and proceed with the balance of the manuscript in Times New Roman font size 12. Set line spacing for the body of the manuscript to double space. Do not indent paragraphs and skip one extra line between paragraphs (2 lines total).

MAJOR HEADINGS: First Headings should be centered on the page, typed with Initial Capital Letters, and in TNR **bold** (font size 14). Two lines should separate First Headings from the text above. Second Headings should be flush with the left margin, Initial Capital

Letters and typed in TNR **bold** (font size 12). Third Headings should be flush with the left margin, Initial Capital Letters, and typed in TRN ***bold/italics*** (font size 12). One line (double space) should separate all headings from the subheading or text below.

PAGINATION: Pages should be numbered sequentially beginning with the second page (page 2). Page numbers should be placed at the bottom of the page (footer) and centered; TNR font size 12.

SYMBOLS AND FORMULAE: Use SI units (or English with SI units) and standard symbols and abbreviations. Do not use periods after abbreviations.

TABLES: The word Table, followed by its Roman numeral, and its title, should be typed above the table itself and centered. The data contained in the table should be set apart from the text paragraphs so as not to be confused with the text. Legends should be typed in the bottom line(s) of the table data. Tables should be typed, spaced as appropriate for clarity, into appropriate positions in the text, without carrying over to the following page. It is preferable to use the "Table" feature in MS Word to create tables. **Boldface** '**Table I.**', **II**, etc., but not the title itself.

FIGURES: Figures should be embedded into appropriate positions in the text. Figure title should be typed below the figure itself and centered. **Boldface** '**Figure 1.**', **2**, etc., but not the caption itself.

EQUATIONS: These can be created using MS Word or other software as appropriate. When numbering equations, place the equation number at the left in square brackets (e.g. [1]), and number subsequent equations separately. Format equation lines with 6 pt above and 6 pt below in the 'Format Paragraph' box.

REFERENCES: In the text, we will accept either consecutive numbers in parentheses on the same line as text, e.g., (1,2) (not superscripted), or the last names of authors, initial capitalized and followed by the year of publication, also in parentheses, e.g., (Shaw, 1982; Shaw and Yakapovich, 1976). With three and more authors use (Johnson et al., 1983) to conserve space. If the author name format results in two or more listings of "Johnson et al., 1983", use 1983a and 1983b, etc., to differentiate. Do not italicize 'et al.', and note that there is no period after 'et'.

In the List of References authors surname should be typed first followed by initials, "article titles", journal title (abbreviated, if possible, in accordance with *The World List of Scientific Periodicals),* volume number, (issue if available), colon, page numbers of the text and (year of publication). For example:

1. Russel, D.H., Medina, V.J. and Snyder, S.H. "Chemistry and Biology", J. Biol. Chem. 245(3):6732-6738 (1970). *or*

Russel, D.H., Medina, V.J. and Snyder, S.H. 1970. "Chemistry and Biology", J. Biol. Chem. 245(3):6732-6738.

References to books should contain authors names in the same format as above, with the title of the book *italicized* (initial capitals for all major words in the title), followed by (the place of publication: Publishers name, year of publication), and page number(s). For example:

1. Yoffe, S.T. and Nesmayanov, A.M. *Handbook of Magnesium- Organic Compounds* (London, England: Pergamon Press, 1956), p. 38. *or*

Yoffe, S.T. and Nesmayanov, A.M. 1956. *Handbook of Magnesium- Organic Compounds* (London, England: Pergamon Press), p. 38.

The full reference list should be typed at the end of the manuscript. The phrase "submitted for publication" is not considered a reference, and should be placed in parentheses at the appropriate place within the text. However, "accepted for publication" or "in press" are acceptable in the reference list.

SUBMISSION: Please submit your manuscript (MS Word format) by email as an attached file to:

Laurie Kormos
Animal Health Manager
Steinahrt Aquarium
California Academy of Sciences
p. 415-379-5437
lkormos@calacademy.org

EXAMPLE ABSTRACT & MANUSCRIPT: The following six pages include an example manuscript that shows all of the main layout components described in the *Instructions to Authors*. PLEASE NOTE that this is a very incomplete manuscript to be used as an example only.

Foam Fractionation versus Ozone Contacting: Impacts on Water Quality in a Natural Seawater System

ROGER PHILLIPS[1]; ERIC KINGSLEY[1]; SARAH MANSERGH[1]; ROBIN WEBER[2]

[1]*Monterey Bay Aquarium, 886 Cannery Row, Monterey CA, 93940, USA*
[2]*University of California, Santa Cruz, 1156 High Street, Santa Cruz, CA, 95064, USA*

Abstract

The Monterey Bay Aquarium Outer Bay Exhibit is a 1.2 million gallon (4,540 m^3) natural seawater system displaying tuna and other pelagic animals. Inconsistent visibility in this exhibit prompted evaluation of life support system components to improve water clarity. Pilot-scale foam fractionation and ozone contacting treatment systems were installed on the Outer Bay system and studies were conducted to determine the effectiveness of each treatment at improving water clarity. Ozone was applied at doses ranging up to 0.3 mg/L in the foam fractionator and up to 1.0 mg/L in the ozone contactor. Changes in water clarity or turbidity were the main focus of these studies; however the use of ozone necessitated monitoring other impacts on water quality. Water quality criteria monitored during these studies included: turbidity, particle size distribution, densities of bacteria (disinfection), dissolved oxygen, pH, oxidation-reduction potential, residual ozone, and the production of residual oxidants (free chlorine, hypobromite and bromate). The foam fractionator reduced the turbidity of system seawater at ozone doses up to 0.1 mg/L. Ozone doses above 0.2 mg/L increased the turbidity of treated seawater in both the foam fractionator and the ozone contactor. Water quality results from foam fractionation and ozone contacting are summarized and compared.

Introduction

Water clarity issues are fairly common in aquariums, especially in large volume exhibits where even very low turbidity can have negative impacts on the visitor experience. Water clarity in the Monterey Bay Aquarium (MBA) Outer Bay Exhibit (OBE) has been declining over the last eight years as fish bioloads and food rations have increased. In 2001 the aquarium funded a project to study water clarity in the OBE and examine ways to improve it with the ultimate goal of proposing changes to the life support system (LSS). Pilot-scale foam fractionation and ozone contacting treatment systems were installed on the Outer Bay system and studies were conducted to determine the effectiveness of each treatment at improving water clarity.

Methods and Materials

The pilot-scale testing system incorporated a small pressurized ozone contactor and a foam fractionator which were sized to model equipment that could be feasibly installed on the Outer Bay system; a small 10-15% side-stream for the ozone contactor, and a ~30% increase in parallel flow through foam fractionation. The ozone contactor skid consisted of a small 13 GPM (0.8 L/s) 316 SS pressurized contactor, a centrifugal degas separator, and a degas relief valve (GDT Water Process Corporation, Phoenix, AZ, USA). The foam fractionator was a RK2 Systems Model 2400 (RK2 Systems Inc., Escondido, CA, USA). Operating parameters for the ozone contactor and foam fractionator are listed in Table I.

Table I. Operating parameters for the ozone contactor and foam fractionator.

Variable	Ozone Contactor	Foam Fractionator
Rated Flow (GPM)	13	28
Rated Flow (L/s)	0.82	1.77
Actual Flow (GPM)	12 – 13	28
Actual Flow (L/s)	0.76 – 0.82	1.77
Pressure (psi)	9.0 – 10.5	NA
Pressure (kPa)	62.0 – 72.4	NA
Gas to Liquid Ratio	0.05 – 0.10	0.37 – 0.38
Hydraulic Retention Time (s)	32 – 34	120
Ozone Dose (mg/L)	0.2 – 1.0	0.0 (Air) – 0.3

The pilot-scale system was installed in the third floor OBE Service Area and SW was drawn from the OBE overflow box. Regulated SW flows could be sent to the ozone contactor, the foam fractionator, or to a by-pass for modeling side-streams (Figure 1).

Post-ozone contactor and post-foam fractionator SW was routed to a small de-aeration tower before entering the mixing tank. Sample ports were located down-stream from the ozone contactor and the foam fractionator, in the by-pass piping, and down-stream from the mixing tank (Figure 1).

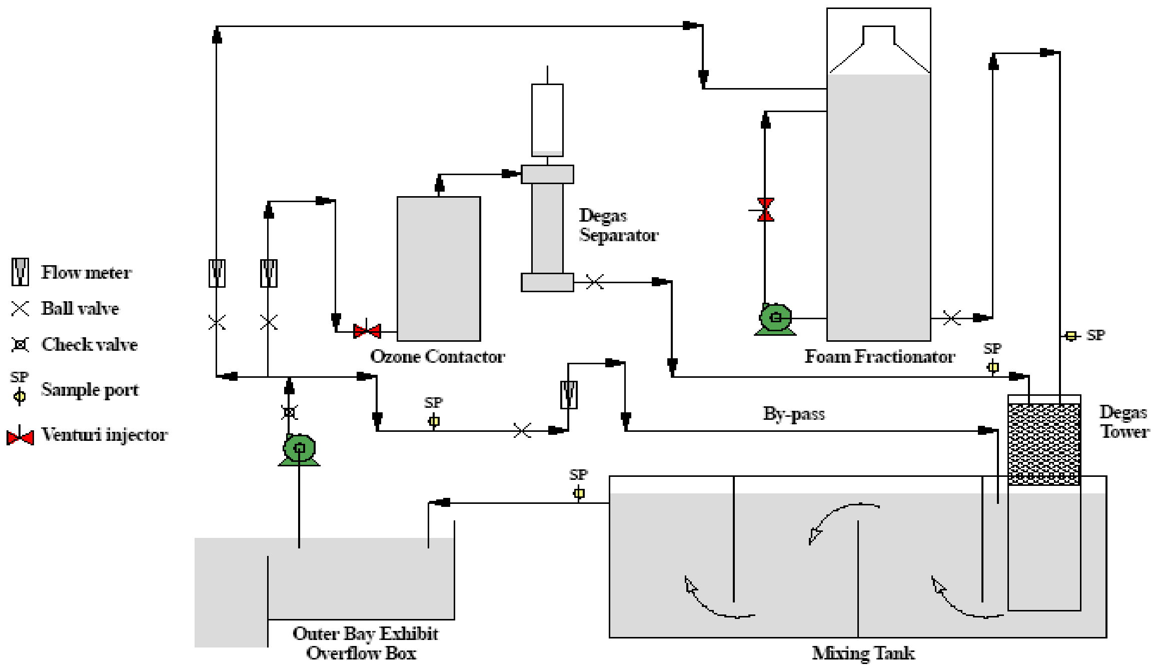

Figure 1. Flow diagram of the pilot scale system.

Ozone was provided by two Ozotech Model OZ-2 2.1 g/h ozone generators that were supplied compressed air through a small air dryer (Ozotech Inc., Yreka, CA, USA; Ozone Water Systems Inc., Phoenix, AZ, USA). The output lines from the generators were joined to a common line which fed a small distribution header. A side-stream from the distribution header was routed to an API Model 454 high-level ozone monitor which measured ozone concentration in the gas phase to allow accurate calculation of ozone applied dose (Advanced Pollution Instrumentation Inc., San Diego, CA, USA).

Results and Discussion

Turbidity, Particle Size Distribution, and Densities of Bacteria in the Outer Bay System

Data demonstrated that turbidity in the Outer Bay system was largely due to particles <1.5 microns in size and that particle densities were driven by fluctuations in bacterial populations which in turn were driven by feeding events. A bloom in the bacterial population was stimulated by increased nutriment (and possibly bacteria) introduced with the food and subsequent fish feces containing both bacteria and nutriment.

Pilot-Scale Studies

Turbidity

Turbidity data were analyzed by calculating the change in turbidity from pre-treatment to post-treatment. These differences were expressed either as mNTU or as a percentage change from pre-treatment turbidity.

Ozone doses of 0.2 mg/L and above increased the turbidity of SW treated in the ozone contactor. At an ozone dose of 0.2 mg/L turbidity increased by an average of about 4% (2 mNTU). At higher ozone doses of 0.5 and 1.0 mg/L the turbidity increase was very dramatic ranging from 24 to 67% (10 to 29 mNTU).

When supplied air alone the foam fractionator reduced the turbidity of Outer Bay system SW by an average of 20% with a range from about 16% to 26%. Fractionator efficiency declined fairly rapidly at ozone doses above about 0.2 mg/L. At an ozone dose of 0.3 mg/L the average change in turbidity was very close to zero and in one experiment the turbidity actually increased above exhibit SW.

Residual Oxidants (Hypobromite, Bromate, & DPD Free Chlorine)

Bromide (Br^-) is a very abundant element in natural SW (67-68 mg/L; Wilson, 1975) and has been shown to have a very high reaction constant with ozone (160 mol/s; Hoigne et al., 1985). Thus, while ozone is available to react with many organic and inorganic compounds in SW, it has a very high affinity for bromide [and iodide which is present at a much lower concentration]. In aquaria with low concentrations of dissolved organic matter, bromide ion is the primary species consuming ozone (Grguric et al., 1994). The bromide in natural SW reacts with ozone very quickly and it is almost impossible to measure residual ozone unless the ozone applied dose is very high (over 1.0 mg/L) or the ozone is not well dissolved. Hypobromite (OBr^-) is produced by the initial reaction of ozone and bromide (Equation 1). Hypobromite is also a strong and unstable oxidant capable of reacting with chemical compounds and biological materials (Grguric et al., 1994). We believe that hypobromite carries out most of the subsequent oxidation and disinfection reactions that ozone was initially intended to perform in natural SW.

$$[1]\quad O_3 + Br^- \rightarrow O_2 + OBr^-$$

$$[2]\quad 2O_3 + OBr^- \rightarrow 2O_2 + BrO_3^-$$

Hypobromite can also react with two additional molecules of ozone to form bromate (BrO_3^-) and oxygen (Equation 2). Bromate is a rather stable oxidant that can accumulate in closed systems when relatively high ozone doses are used. Any residual oxidants are to be avoided or at least minimized in live systems due to their potentially harmful effects to the animal collection (Grguric et al., 1994).

Summary

The results of the pilot-scale studies focused our efforts on foam fractionation to improve water clarity in the Outer Bay system, and we are currently installing 2,400 GPM (152 L/s) of parallel-flow fractionation on this system. This LSS addition will reduce total system turnover through "filtration" to about 2 hours. We continue to monitor water quality and clarity in this system and will document changes when the fractionators become operational.

Acknowledgements

The pilot-scale system would not have been possible without the assistance of Mark Fisher and John Overby from Ozone Water Systems Inc, Phoenix, AZ. Many thanks to Michael Alden, Bechman Coulter, for allowing us to use the Multisizer 3 Coulter Counter.

References

Grguric, G., Trefry, J.H. and Keaffaber, J.J. 1994. "Ozonation Products of Bromine and Chlorine in Seawater Aquaria", Water Research 28(5):1087-1094.

Hoigne, J., Bader, H., Haag, W.R. and Staehelin, J. 1985. "Rate Constants of Reactions of Ozone with Organic and Inorganic Compounds in Water – III. Inorganic Compounds and Radicals", Water Research 19(8):93-1004.

Wilson, T.R.S. 1975. Salinity and the major elements of sea water. In: Riley, J. P. and Skirrow, G., editors. *Chemical Oceanography* (London, England: Academic Press), p. 365-413.