Supplementary Information

A desktop assessment of ozone micro-nanobubble technology for algae and PFAS removal from surface water bodies using opensource water quality data

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Table S1: Laboratory or on-site studies conducted using ozonation for algae treatment in surface water entities.

Source/Article	Used Technology	location	Max reduction achieved	Water quality	Remarks
[1]	Ozone and permanganate as preoxidants	Cheng Ching Lake, Taiwan (Lab test)	93% removal of algae	Temperature 16.6 – 31.3 ^{0}C pH 7.9 – 8.7 DO 5.7 – 11 mg/L	• 1-7 mg/L of ozone • The removal rate was 93% using 3 mg/L . A further increase of ozone reduced the reduction level due to the cell lysis releasing cyanotoxins • Ozone used as a preoxidant helped coagulation, the addition of calcium further helped the removal when using alum doses
[2]	Ozonation	Reservoirs in South Australia (Lab test)	100% reduction of two cyanotoxins	pH 7.1 – 7.8 DOC 4.6 – 15.5 mg/L	• There is no one-glove suits all solution, and the reduction is based on a conglomerate of the water qualities. Although lab tests show 100% reduction, this may not hold true in the field due to changing parameters

[3]	Activated carbon catalysed ozonation (ACCO)	A drinking water reservoir, Iran (Lab test)	92.6% removal of algae	pH 8.5 DOC 1.9 mg/L	• ACCO showed a 90% reduction in algae which is less than using ozone alone, however, using ACCO decreased the turbidity compared to ozonation, and whilst ozonation increased DOC, ACCO decreased DOC by 76%
[4]	Coagulation, ultrafiltration, ozone and biologically activated carbon	East Taihu Lake, China (On-site)	95.9% of algae removed	pH 7.9	• Total nitrogen was reduced by 81% • DBP were formed during coagulation, however, the integrated process removed the DBP
[5]	Ozone assisted biological filtration	Saskatchewan, Canada (On-site)	96% removal of algae	pH 7.9 – 9.2 DOC 12 – 35.6 mg/L	• The water was treated for the potable use of two rural communities • High alkalinity inhibited the reduction of DOC using ozone • Despite the two surface water sources having similar qualities, the treatment methods need to be different

Table S2: Laboratory or on-site studies conducted using ozonation for PFAS treatment in surface water entities.

Source/ Article	Used Technology	Location	Reduction	Water properties	Remarks
[6]	Activated carbon, filtration, and ozonation	South East Queensland, Australia	Complete removal of PFOS and other long-chain PFAS. Short-chain PFOS were not completely removed	Dry climate pH 4	• Several stages of ozonation were applied ranging from 2 – 5 mg L^{-1} • PFBS, PFHxS, PFOS, PFHxA, PFOA, PFNA, PFDA, PFHpA
[7]	Alkaline ozonation	Science Park of Hsinchu City, Taiwan	Removal of PFOA and PFOS by 85%-100%	Windy weather pH 11	• Ozone concentration of 0.3 mgL^{-1}
[8]	• Ozone fractionation • UV/ozone	Laboratory	Up to 95% of PFAS removal using ozone fractionation. 73% removal rate of PFAS using UV/ozone	Room temperature	• Hydraulic residence time of 20 mins • Air flow rate of 20 L min^{-1} • PFHxS, PFOS, PFHxA, PFOA; PFPeS, PFHpS, PFPeA, PFAS
[9]	Catalyzed ozonation with persulfate	Laboratory in Stockholm University, Sweden	77% removal of PFAS in laboratory-scale trials.	Room temperature (22 °C) pH 7.5	• Laboratory and pilot-scale experiments • 300 mg of ozone per hour • 187 mg ammonium persulfate

	A maximum of 70% removal of PFAS in pilot-scale trials.	• PFOA, PFNA, PFDA, PFUnDA, PFOS, FOSA, PFPeA, PFHxA and PFHpA

Table S3: Laboratory or on-site studies conducted using ozonation and/or MNBT for algae treatment in surface water entities.

Source/Article	Used Technology	location	Max reduction achieved	Water quality	Remarks
[10]	MNTB + ozone	Hong Kong (Lab testing)	96%	Temperature 18.5 - 24.1 ^{0}C	• Treatment carried for three days out of four • 65% reduction just after 0.025 ppm ozone treatment, and increased to 75% within 24 hours. • 96% reduction after 0.15 ppm treatment for a further two days using NTB. • Algal concentration was only in the magnitude of 10^3
[11]	NBT + O3	Wisconsin, USA (Lab testing)	100% algae mortality rate	Temperature 15 – 28 ^{0}C pH 6.5 - 9 EC 120 – 170 μS/cm DO 4 –12 mg/L	• There was an increase in the temperature by about 1 -1.5 ^{0}C after a four-hour treatment
[12]	NBT + O_2	Naples, Florida, USA (On-site)	DO increased by 41%	Temperature 26 – 32 ^{0}C	• Treatment duration was 8 weeks • Pond Volume was 9500 m^3
[13]	NBT + O_2	Vero Beach Golf Course, Florida (On-site)	DO increased from 1 to 8 mg/L	Temperature 26 – 32 ^{0}C	• Treatment lasted for 3 months • Pond Volume was 123,348 m^3
[14]	NBT + O2	Emirates Golf Club, Dubai, UAE (On-site)	DO increased from 4 to 6.1 mg/L	DO 4 mg/L	• Volume 15,000 m^3 • Treatment for 3 months • Recirculating flowrate of 6 m^3/h

[15]	Chitosan modified NB	Wangsong reservoir, South Korea (Lab testing)	Algal cell inactivation rate was 75% for the modified NB	pH 7.6	• The modified NBs produced more hydroxyl radicals than the NBs alone. The modified NBs were larger in size but had a lower concentration. • NBs and M.aeruginosa have negative zeta potential whilst the chitosan NB have a positive zeta potential
[16]	Modified local soil using chitosan and oxygen NB-modified zeolite	Cetian Reservoir, Shanxi province, China (On-site)	75% of algal cells removed	pH 8.9 DO 5.9	• The project was carried out for a span of 3 years
[17]	Ozone micro-bombs	Shangtang River, Hangzhou, China (Lab testing)	Over 93.2 % of Microcystis aeruginosa cells	$6.7 \times 10^5 – 9.88 \times 10^6$ cells/mL	• MB filled with ozone and with an aluminium surface • Reduction was observed within 5 minutes • Removal of cyanotoxins occurred during lysis by 66.1% - 98.4% depending on intra or extracellularity

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