

APPLICATION REPORT • INVASIVE SPECIES CONTROL

Zebra & Quagga Mussel Control with DZ 9966

A liquid mineral-oxychloride reactive-oxygen-species (ROS) reagent that clears biofilm and mussels from raw-water intakes, pipes, screens, and cooling systems — delivering ozone-class oxidation with a lasting residual ORP.

~+650 mV

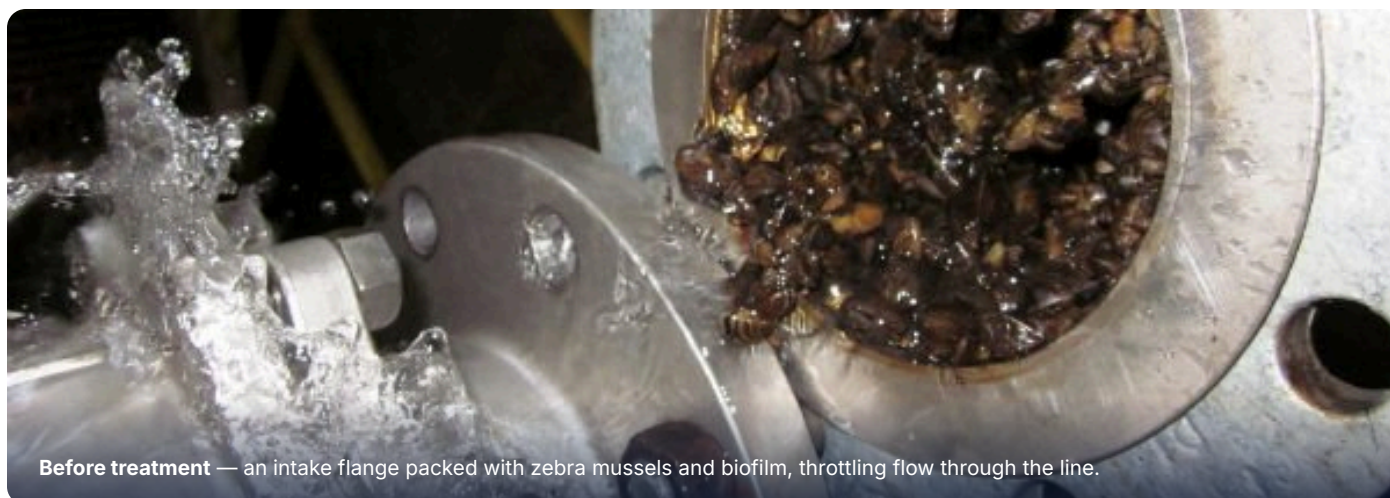
TARGET ORP CONTROL SETPOINT

100%

ADULT & VELIGER MORTALITY

6.60 log

MICROBIAL REDUCTION AT 10 PPM



Before treatment — an intake flange packed with zebra mussels and biofilm, throttling flow through the line.

— The Biofouling Problem

First found in Lake St. Clair in 1988 — and believed to have arrived in ballast water from the Black and Caspian seas around 1985 — the zebra mussel (*Dreissena polymorpha*) spread rapidly across the Great Lakes and down the Ohio, Cumberland, Arkansas, Tennessee, and Mississippi rivers to New Orleans. The closely related quagga mussel (*D. bugensis*) and the Asiatic clam (*Corbicula fluminea*) followed the same path. These mollusks invade water utilities, clogging transmission lines, valves, screens, and meters, damaging centrifugal pumps, and causing taste-and-odor problems.

Adult mussels (6–45 mm) anchor by byssal threads and are far more resistant to oxidants than their free-floating veliger larvae. Conventional control leans on free chlorine — but at the doses and contact times mussels demand, chlorine forms excessive trihalomethanes (THMs), is highly toxic to non-target fish and invertebrates, and requires dechlorination before discharge.

— Ozone-Class Oxidation — With a Residual

Chlorine dioxide and ozone prove that reactive oxygen species handle both organic loading and target pests far better than chlorine — but neither is cost-effective, and ozone dissipates so fast it leaves no residual to protect downstream piping.

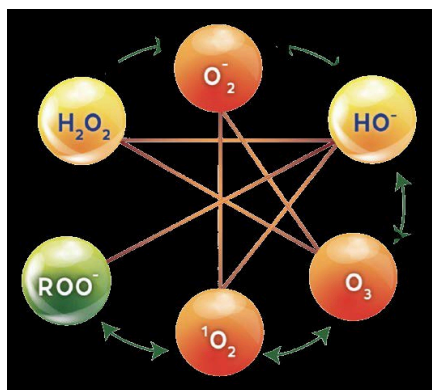
DZ 9966 delivers a family of ROS in a stable liquid, providing oxidation potential almost equal to ozone with the added benefit of **residual oxidation energy**. Chemically it is a chelation of minerals with oxygen (mineral oxychloride, MOxC), purposely weakly bound so that on contact with inorganics, microbes, and organic matter it readily gives off ROS — hydroxyl radical, singlet oxygen, superoxide, and peroxide — that aggressively oxidize contaminants.

A water shell around each metal-oxy-complex conserves its energy, delivering a measurable, lasting ORP rather than a single spent dose. The reaction is effectively catalytic: it lowers the activation energy for oxidizing organic material, then the minerals return to ground state. The mineral-oxide by-products are themselves mildly biocidal — guarding against bacterial recontamination — and fall well below FDA maximum contaminant levels.

OXIDATION POTENTIAL OF COMMON OXIDANTS

REAGENT	FORMULA	VOLTS
Fluorine	F ₂	3.06
Mineral Oxychloride	M _x O _y Cl _z	2.8–2.9
Hydroxyl Radical	OH•	2.80
Oxygen Ion	O ⁻	2.42
Ozone	O ₃	2.07
Hydrogen Peroxide	H ₂ O ₂	1.78
Perhydroxyl Radical	HO ₂	1.70
Chlorine Dioxide	ClO ₂	1.57
Hypochlorous Acid	HOCl	1.49
Chlorine Gas	Cl ₂	1.36
Oxygen (Molecule)	O ₂	1.23
Hypochlorite Ion	OCl ⁻	0.94
Sodium Hypochlorite	NaOCl	0.94
Hydroperoxide Anion	HO ₂ ⁻	-0.88
Superoxide Radical	O ₂ ⁻	-2.40

THE DZ 9966 ROS FAMILY



REACTIVITY OF DZ 9966 — DOSE RATIOS

TARGET	EFFECTIVE CONCENTRATION
Inorganics	< 1.0 mg/L per 1.0 mg/L inorganic
Pathogens	1.0 mg/L per 1,000–10,000 mg/L pathogen
Organics	1.0–8.0 mg/L per 1.0 mg/L organic
Residual	Mineral-oxide by-products resist recontamination

Unlike chlorine, mineral oxychloride releases single oxygen atoms embedded within the molecular structure of organics and pathogens — killing microbes rather than poisoning them, so more is accomplished with less.

— How DZ 9966 Compares

Field and laboratory studies show the dose and contact time required to kill these mollusks are extremely high for conventional oxidants. Measured as LT_{50} — the time to 50% mortality — DZ 9966 matches ozone's best performance while holding a controllable $\sim +650$ mV ORP setpoint at neutral pH.

OXIDANT	RESIDUAL (mg/L)	ORP (mV)	TEMP (°C)	pH	STAGE	LT_{50} (DAYS)
Free chlorine	0.5	NA	23	8.0	A	8.7
	4.8		21	7.9	A	5.9
	4.7		16	7.8	J	4.8
Potassium permanganate	1.1	NA	17	7.6	J	7.9
	4.8		17	7.6	J	8.6
Monochloramine	2.6	NA	28	7.9	J	0.6
	10.7		17	7.9	J	0.5
Chlorine dioxide	1.2	NA	24	6.9	J	0.7
	4.7		22	6.6	J	0.6
Ozone	0.5	NA	17	7.0	A	4
	0.5		17	7.0	J	0.2
DZ 9966	0.5	$\sim +650$	17	7.0	A	4
	0.5	$\sim +650$	17	7.0	J	0.2

A = adult, J = juvenile. Compiled after Cameron et al. (1989); ozone extrapolated from EPA data. DZ 9966 dosed to an ORP setpoint rather than a fixed residual.

— Application & Effect Ranges

TREATMENT	APPLICATION	EFFECT
Chlorination (adults)	0.5 ppm for 7 days	75% kill
Chlorination (adults)	2 ppm, continuous flow	> 95% kill
Chlorine dioxide	0.5 ppm for 24 hr	90% kill
Chloramine	1.2 ppm for 24 hr	100% veliger kill
Ozone	0.5 ppm for 5 hr / 7–12 days	100% veliger kill
DZ 9966	$\sim +650$ mV for 5 hr / 7–12 days	100% veliger & 100% adult kill

After McMahon, Lussery & Clarke (1994). Strategy is chosen per facility — continuous or semi-continuous dosing prevents settlement where no macrofouling can be tolerated; intermittent, periodic, and end-of-season programs manage established infestations.

— Proven Microbial Kill

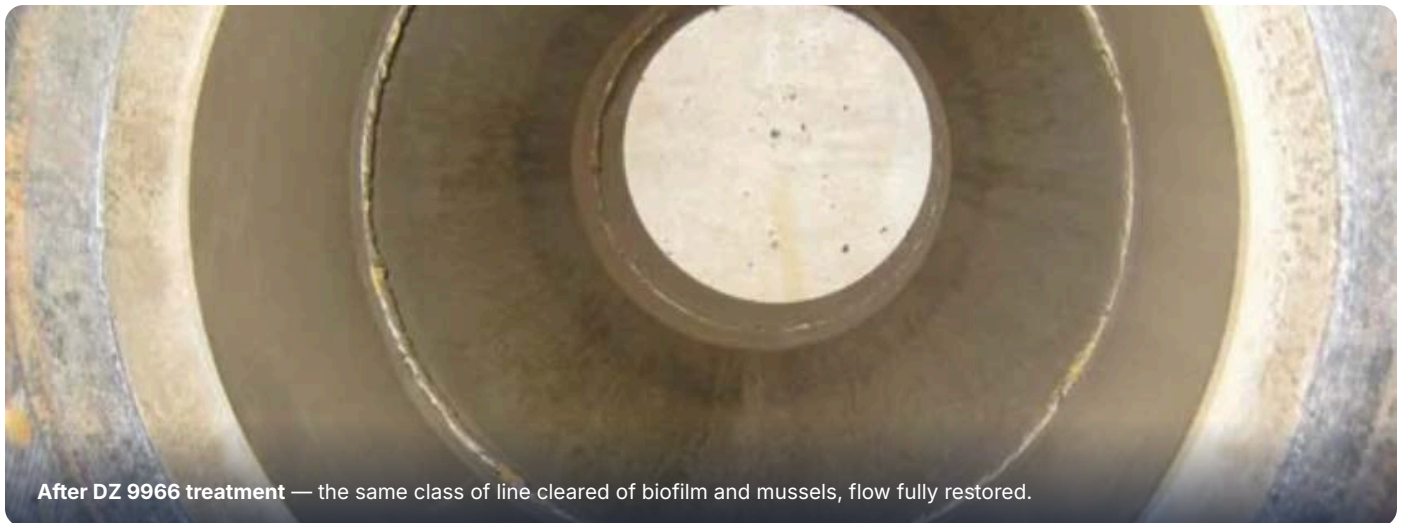
In pre-registration testing, an independent microbe-specialty laboratory ran kill assays against *Salmonella enterica* (10708). At just **10 ppm**, DZ 9966 drove a 6.60-log reduction in 30 minutes — outperforming sodium hypochlorite dosed ten times higher, at 100 ppm.

SOLUTION	PPM	CFU/mL, TIME ZERO	CFU/mL, 30 MIN	LOG REDUCTION
Hypochlorite	10	2.00×10^7	1.89×10^5	2.02
Hypochlorite	100	1.58×10^7	< 5	6.49
DZ 9966	10	2.00×10^7	< 5	6.60

Salmonella enterica 10708 assay from DZ 9966's pre-registration testing.

RESULT

More kill, less product. DZ 9966 achieved a full veliger and adult mussel kill and a 6.60-log microbial reduction at one-tenth the dose of chlorine — with mineral-oxide residues that resist recontamination and fall well below FDA maximum contaminant levels.



After DZ 9966 treatment — the same class of line cleared of biofilm and mussels, flow fully restored.

Ozone-Class Oxidation

Residual ORP Protection

Residues Below FDA MCL

EPA FIFRA Registered

For application engineering, dosing trials, and ORP-controlled feed design, contact D&Z Worldwide — deepak@dz-worldwide.com • www.dz-worldwide.com