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Is all salinity the same? I. The effect of ionic compositions on the salinity tolerance of five species of freshwater invertebrates

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Abstract. Salts of marine origin, predominantly consisting of Na^{+} and Cl^{-} ions, are dominant in most Australian inland saline waters. The proportions of other ions, Ca^{2+}, Mg^{2+}, SO_4^{2-}, HCO_3^{-} and CO_3^{2-}, in the water may influence salinity tolerance of freshwater organisms and thus the effect of increasing salinity may vary with difference in ionic proportions. We exposed freshwater invertebrates to different concentrations of four ionic compositions and compared them with commercial sea salt (Ocean Nature). They were: synthetic Ocean Nature (ONS) and three saline water types (ONS but without: SO_4^{2-}, HCO_3^{-} and CO_3^{2-} (S1); Ca^{2+}, HCO_3^{-} and CO_3^{2-} (S2); and Ca^{2+} and Mg^{2+} (S3)), which are considered to be the predominant saline water types in south-eastern Australia and the Western Australian wheatbelt. The 96-h LC_{50} values for the five media were determined for six invertebrate species and sub-lethal responses were observed for two species. There were no differences between responses of invertebrates to various ionic compositions in acute toxicity tests. However, in prolonged sub-lethal tests, animals reacted differently to the various ionic compositions. The greatest effect was observed in water types lacking Ca, for which plausible physiological mechanisms exist. Variation in ionic proportions should be taken into account when considering sub-lethal effects of salinity on freshwater invertebrates.

Table 1. Water quality data from collection sites

Date	Site	Species collected	Air temperature (^oC)	Water temperature (^oC)	Electrical conductivity ($\mu S\ cm^{-1}$)	pH	DO (% saturation)
21/09/04	King Parrot Creek	*Notalina fulva* *Micronecta robusta* *Centroptilum* sp.	10	9.3	42	7.36	117
11/10/04	Campaspe River	*Physa acuta*	17.2	16.2	626	6.5	95
19/10/04	Campaspe River	*Physa acuta*	16.2	15.3	625	7.03	95

Table 2. Composition (mg L^{-1}) of stock solutions of different types

Compounds with a concentration < 5 mg L^{-1} were concentrated 1000 times and combined to prepare a stock solution (1 mL was added per 1 L of the final solution)

Compound	ONS	S1	S2	S3
$CaCO_3$	55.5	-	-	-
NaCl	23290.6	23412.4	23290.6	26757.3
KCl	653.8	653.8	653.8	653.8
$MgSO_4*7H_2O$	5957.7	-	5957.7	-
$FeSO_4*7H_2O$	1.1443	-	1.1443	1.1443
$MnCl_2*4H_2O$	4.8885	4.8885	4.8885	4.8885
LiCl	1.0494	1.0494	1.0494	1.0494
$SrCl_2*6H_2O$	21.3	21.3	21.3	21.3
$Na_2MoO_4*2H_2O$	1.0423	1.0423	1.0423	1.0423
$CuCl_2*2H_2O$	0.0097	0.0097	0.0097	0.0097
$ZnCl_2$	0.0875	0.0875	0.0875	0.0875
$CoCl_2*6H_2O$	0.1411	0.1411	0.1411	0.1411
SeO_2	0.1236	0.1236	0.1236	0.1236
NH_4VO_3	0.0690	0.0690	0.0690	0.0690
$CaCl_2*2H_2O$	1200.7	1282.2	-	-
$Na_2SiO_3*9H_2O$	16.4	16.4	16.4	16.4
$NaNO_3$	2.0521	2.0521	2.0521	2.0521
KH_2PO_4	1.4298	1.4298	1.4298	1.4298
H_3BO_3	12.3	12.3	12.3	12.3
$MgCl_2*6H_2O$	4367.5	9201.6	4367.5	-
KI	0.0916	0.0916	0.0916	0.0916
$NiSO_4*6H_2O$	0.296	-	0.296	0.296
$NaHCO_3$	174.9	-	-	221.6
RbCl	0.1556	0.1556	0.1556	0.1556
NaBr	24.5	24.5	24.5	24.5
$FeCl_3*6H_2O$	-	1.1132		
$NiCl_2*6H_2O$	-	0.2673		
Na_2SO_4				3435.7
TDS	30083.82	29402.36	29573.5	31121.02

S1: SO_4^{2-}, CO_3^{2-}, HCO_3^- excluded

S2: Ca^{2+}, CO_3^{2-}, HCO_3^- excluded

S3: Ca^{2+}, Mg^{2+} excluded

TDS: total dissolved solids

Table 3. Analysis of major ions content of the stock solutions for different treatment types and diluent waters (mg L^{-1})

Electrical conductivity (EC) is in mS cm^{-1}

Water type	Ca	Mg	K	Na	Cl	SO_4	CO_3	HCO_3	EC
WLW	6.8	2.1	1	8.9	15	9.6	<5	23	0.126
M4	69	13	3.1	30	110	49	<5	64	0.628
ON	110	340	120	2880	4800	790	<5	<5	17.09
ONS	92	350	120	2870	4700	730	<5	69	16.26
S1	84	160	110	2700	4600	0.5	<5	14	15.24
S2	0.11	350	120	2730	4500	720	<5	14	15.59
S3	0.11	0.019	100	2720	4200	0.3	<5	50	13.81