International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(1): 108-116
© 2021 IJCS
Received: 05-01-2021
Accepted: 14-02-2021

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Effect of different cultural methods on chemical properties of saline water

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DOI: https://doi.org/10.22271/chemi.2021.v9.i2b.11708

Abstract
The increased water scarcity made the people dependent the poor quality saline water largely for agriculture and other uses. There are numerous techniques have been employed to remediate them yet they are incomplete as many of them failed to satisfy the eco-friendly and cost effective. It is aimed to develop eco-friendly techniques for amelioration of saline water chemical properties at source point to fit it more agriculture use. In this regard, saline waters 2.0, 4.0, 6.0 and 8.0 dS m^{-1} were treated with indigenous materials *viz*. Amla stem powder, Muringa seed powder, Tattamparai Seeds powder, dried lemon fruit powder and coconut shell biochar @ 4 g L^{-1} and 6 g L^{-1} were used for incubation duration of six hours and twelve hours. Results revealed that electrical conductivity, calcium, magnesium, sodium, chloride and sulphate content and their effect size decreased significantly with increase of saline water EC. The six gram materials and six hours incubation were optimized for the significantly a greater effect. As the materials and dose effect varied significantly saline water levels, the Amla wood indigenous materials 6 g L^{-1} was very effective for all saline waters and the highest effect was 55.3% EC reduction recorded the in the 2 dS m^{-1} saline water. The ions removal for cultural methods was in the decreasing order; $Ca^{2+} > Mg^{2+} > Na^{+} > SO_4^{2-} > Cl^{-}$. Even though it is appeared a promising and the ecological oriented method for amelioration of different kind industrial waste saline water, the availability of such amount and laborious will be a constraint for the practical utility in agriculture.

Keywords: Indigenous materials, saline water amelioration, ionic concentration, irrigation water quality

Introduction
Water demand increased in all sectors with increasing world population and intensified economic activities. Since, the available fresh water is not adequate to meet the demand, the available poor quality water is the only option to be managed with for various purposes. The poor quality water has already been widely used in agriculture particularly arid and semi-arid region as the water scarcity is almost regular phenomena n the recent time (Murtaza *et al*. 2019) [18]. Besides the marginal water present in surface and underground source, there are huge amount of waste being produced every day be led into running fresh water streams or and terrain without appropriate treatment impairing the sustainability of natural resource (Vadivel *et al*. 2014) [22]. There are some cases the industrial waste water used for agriculture at appropriate dilution with good quality water or reduced amounts mainly to derive the cheap nutrient sources. In this aspect, technology upon promising in removal of insoluble and soluble pollutants this can be a water source for agriculture (Baskar *et al*. 2013; Jain and Srivastava 2012) [1, 4, 13].

There are different approach being used to treat industrial waste water which shows removal of chemical pollutants and a moderate improvement of water quality. Ion exchange, precipitation, adsorption and chelation are the mechanism adapted for pollutant removal and improving treatment efficiency by providing the appropriate treatment situation (Bharagava, R. N., & Chowdhary, 2019) [2]. Activated carbon, homo and cross-linked hetero polymers and ion-exchange resins and biosorbent are the exemplifications for effective removal of different chemical pollutants present in industrial waste water (Charles *et al*. 2016; Ismail and Mokhtar, 2020) [5, 12]. Moreover, the combined approach of one or more techniques results a higher removal of chemical pollutants being recommended for all kinds of industries waste water treatment (Ismail, 2020) [12].

For instance, The mixture of activated carbon and cation and anion resins lowered Cu, Ni and COD, the main pollutants present in the discharge water, by more than 96%, 79% and 74% respectively, while carbon alone lowered them by 58%, 9% and 70%, and resins alone by 85%, 61% and 16% (Charles *et al*. 2016) [5]. Recently, many papers advising for use agriculture waste material as a bio-sorbent for amelioration heavy metals and the ions responsible for hardness of water such as calcium and magnesium. The elephant foot yarm skin has been proved successfully synthesised in the laboratory condition for removal the calcium and magnesium present in irrigation water. The adsorption capacity for the modified residue was 27.64 and 20.10 mg g^{-1} respectively for calcium and magnesium (Lestari *et al*. 2018) [15]. Functional polymers dominated with amine containing show prominence for calcium and magnesium adsorption based removal and the accompanying anionic counterpart as well (Figaroa *et al*. 2017) [8] but the cations removal was the dominant over anions. Charles *et al*. 2016 [5] reported that the calcium can compete with heavy metal in chelation based removal process and the chelation and ion exchanged based phenomena by which the chloride, sulphate, calcium, magnesium and sodium, eventually the electrical conductivity waste water reduced using the mixed resins and the starch and cyclodextrin cross-linked polymers. As like anionic polymers, the natural organic polymeric substance present in indigenous materials can act like resin to remove those ions but they are less effective (Thomas *et al*. 2012; Li *et al*. 2019) [21]. Thus, biosorbents with enhanced surface properties and improved function sites can be used for adsorbed based abatement and eventually the improvement of irrigation water quality. This paper narrate the aim to identify the best indigenous material and standardize dose and duration for abatement of different kind's cations and anions present in saline water.

Materials and Methods

A laboratory experiment was conducted following factorial completely Randomized Design with four factors. The indigenous materials of five types namely Amla wood, Muringa seed, Tattamparai seed powder, dried lemon fruit powder and coconut shell biochar, saline water having 4 levels of EC 2, 4, 6 and 8.0 dS m-1, material doses of 4 g L-1 and 6g L-1 and the incubation duration of 6 hours and 12 hours. The indigenous materials treated with acid in order to improve the surface properties related adsorption and facilitate the removal of loosed bound cations and anions. In this regard, the diluted 0.01 M hydrochloric acid was added at 1:1 ratio and they incubated for overnight allowing for completion of chemical reaction. The materials then washed with distilled water until the removal chloride.

The indigenous material added to 50 ml saline water at the recommended dose and duration of incubation. After the completion of experiment, the indigenous materials separated by filtering the saline water. The filtered saline waters analyzed for EC, pH, captions (Ca^{2+}, Mg^{2+}, Na^{+}) and anions (Cl^{-} and SO_4^{2-}) concentration (meq L^{-1}). The pH, EC (dS m^{-1}), CEC, surface area (m2 g^{-1}) and cation exchange capacity (cmol (P^{+}) kg^{-1}) was analyzed following standard procedure given in the literatures. Since the experimental unit as well as observational unit was the same heterogeneous materials, percent decline over the control data used for analysis of variance. The SPSS 16.0 statistical package was used for data analysis.

Results and Discussion

Basic characteristics of indigenous materials

The basic characteristic of indigenous materials and the acid treatment effect on the basic properties was also given in the table 1. The pH, EC decreased after the acid treatment while the surface area and CEC increased after the acid treatment. There are different kinds acid and alkali used to brings modification in the physicochemical properties of indigenous materials in order to achieve high adsorption capacity. The treatment effect depends on kind of oxidizing materials used and characteristics adsorbent used (Gisi, 2016) [6]. For instance, Martín-Lara *et al*. 2013 reported that the surface area, number of active binding sites and ion-exchange properties increased with formation of new functional groups in the olive stone after the acid treatment of 2 M sulfuric acid and nitric acid treatment.

Effect of cultural methods on electrical conductivity of saline waters

The saline water EC decreased significantly for indigenous materials, saline waters, and materials dose. The per cent decline of EC value for indigenous materials varied from 29.2% to 20.1%. The Amla stem powder (M_1) registered the significantly higher decline of EC value (29.2%). The saline water EC value and the declining efficiency reduced with increase of saline water EC. The higher efficiency was 41.7% reduction in the 2.0 dS m^{-1} saline water (Fig 1). Similarly, the declining was significantly high for 6 g L^{-1} dose which was around 28% (Fig 2). However, there was an insignificant and high EC declining efficiency was observed at 6 hours incubation at 23.5% (Fig 3). However, the declining saline water EC significantly varied for the interactive effect of indigenous materials, saline waters and materials dose. The high EC reduction was observed in the treatment of Amla stem powder at 6 g L^{-1} for 6 hours incubation in all the saline water, which was the decline of 55.3%, 33.3%, 23.8% and 17.1% respectively in 2.0, 4.0, 6.0 and 8.0 dS m^{-1} saline water. However, the same treatment of 6 g L^{-1} for 6 hours incubation (T_3) had very less decline for coconut biochar and dried lemon powder in all the saline water (Table 1).

Table 1: Basic characteristics of indigenous materials before and after acid treatment (Mean of three replications)

Tr. No.	Materials	pH		EC_e		CEC (Cmol (P^{+}) kg^{-1})		Surface area (m^2 g^{-1})	
		Before acid treat.	After acid treat.	Before acid treat.	After acid treat.	Before acid treat.	After acid treat.	Before acid treat.	After acid treat.
M_1	Amla stem powder	6.82	5.00	0.32	0.02	46.54	51.20	98.30	108.94
M_2	Muringa seed powder	7.00	5.20	0.45	0.01	44.32	48.30	96.56	104.53
M_3	Seeds of Tattamparai	5.70	5.50	0.21	0.02	41.82	45.60	94.54	100.02
M_4	Lemon fruit powder	6.80	5.60	0.28	0.03	38.54	42.10	93.23	97.84
M_5	Coconut Biochar	7.60	5.80	0.34	0.01	35.21	38.70	84.25	88.56

Table 2: Effect of indigenous technologies on electrical conductivities of saline waters (Mean of three replications)

Treat No.	Treatments	Electrical conductivities (dS m^{-1})					Mean
		M_1	M_2	M_3	M_4	M_5	
T_1	*S_1 water (2.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	1.28	1.33	1.45	1.55	1.65	1.45
		(41.28)	(38.99)	(33.49)	(28.90)	(24.31)	(33.39)
T_2	S_1 water (2.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	1.18	1.25	1.40	1.50	1.60	1.39
		(45.87)	(42.66)	(35.78)	(31.19)	(26.61)	(36.42)
T_3	S_1 water (2.0 dS m^{-1}) + Dose six (g L^{-1}) + 6 hrs incubation	1.00	1.10	1.20	1.18	1.25	1.15
		(54.13)	(49.54)	(44.95)	(45.87)	(42.66)	(47.43)
T_4	S_1 water (2.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	0.95	1.04	1.14	1.15	1.20	1.10
		(56.42)	(52.29)	(47.71)	(47.25)	(44.95)	(49.72)
T_5	S_2 water (4.0 dS m^{-1}) + Dose four (g L^{-1} + 6 hrs incubation	3.10	3.22	3.36	3.47	3.56	3.34
		(26.01)	(23.15)	(19.81)	(17.18)	(15.04)	(20.24)
T_6	S_2 water (4.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	3.00	3.14	3.31	3.40	3.50	3.27
		(28.40)	(25.06)	(21.00)	(18.85)	(16.47)	(21.96)
T_7	S_2 water (4.0 dS m^{-1}) + Dose six (g $L^{-1)}$ + 6 hrs incubation	2.82	3.00	3.10	3.08	3.16	3.03
		(32.70)	(28.40)	(26.01)	(26.49)	(24.58)	(27.64)
T_8	S_2 water (4.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	2.77	2.95	3.05	3.03	3.11	2.98
		(33.89)	(29.59)	(27.21)	(27.68)	(25.78)	(28.83)
T_9	S_3 water (6.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	5.06	5.16	5.30	5.42	5.52	5.29
		(18.65)	(17.04)	(14.79)	(12.86)	(11.25)	(14.92)
T_{10}	S_3 water (6.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	4.94	5.10	5.24	5.34	5.46	5.22
		(20.58)	(18.01)	(15.76)	(14.15)	(12.22)	(16.14)
T_{11}	S_3 water (6.0 dS m^{-1}) + Dose six (g L^{-1}) + 6 hrs incubation	4.76	4.95	5.02	5.03	5.10	4.97
		(23.47)	(20.42)	(19.29)	(19.13)	(18.01)	(20.06)
T_{12}	S_3 water (6.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	4.72	4.90	4.98	5.00	5.06	4.93
		(24.12)	(21.22)	(19.94)	(19.61)	(18.65)	(20.71)
T_{13}	S_4 water (8.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	7.04	7.12	7.24	7.37	7.49	7.25
		(12.87)	(11.88)	(10.40)	(8.79)	(7.30)	(10.25)
T_{14}	S_4 water (8.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	6.92	7.07	7.19	7.29	7.43	7.18
		(14.36)	(12.50)	(11.01)	(9.78)	(8.04)	(11.14)
T_{15}	S_4 water (8.0 dS m^{-1}) + Dose six (g $L^{-1)}$ + 6 hrs incubation	6.72	6.91	6.98	6.99	7.06	6.93
		(16.83)	(14.48)	(13.61)	(13.49)	(12.62)	(14.21)
T_{16}	S_4 water (8.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	6.68	6.86	6.95	6.97	7.03	6.90
		(17.33)	(15.10)	(13.99)	(13.74)	(13.00)	(14.63)
	Mean	3.93	4.07	4.18	4.24	4.32	
		(29.18)	(26.27)	(23.42)	(22.19)	(20.09)	
		Materials (M)		Treatments (T)		MXT	
	SEd	(1.00)		(1.45)		(2.35)	
	CD (5%)	(2.00)		(3.90)		(4.70)	
Saline waters	S1	S2		S3		S4	
Initial value (dS m^{-1})	2.00	4.00		6.00		8.00	

*Two gram dose of materials incubated in 2.0 dS m^{-1} saline water for 6 hours: ()-per cent decline of EC value used for anova test: M_1- Amla stem powder; M_2- Muringa seed powder; M_3- Seeds of Tattamparai; M_4- Lemon fruit powder; M_5- Coconut shell biochar

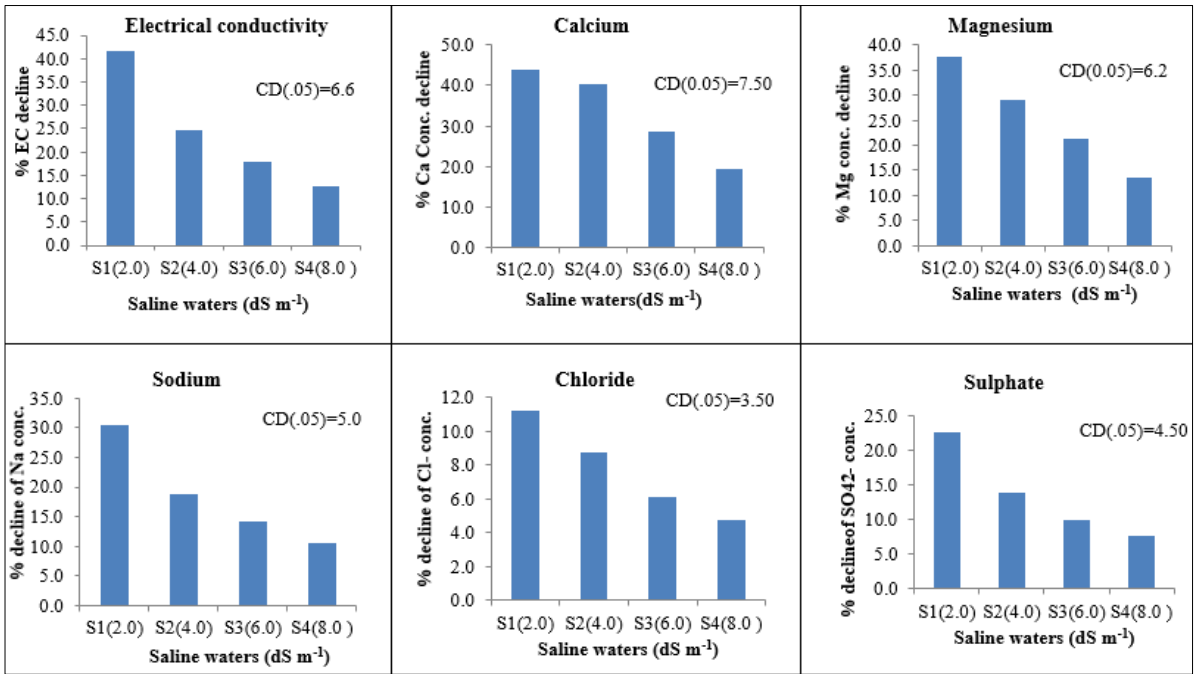

Fig 1: The salinity effect on declining of EC, calcium, magnesium, sodium, chloride and sulphate ion concentration for amelioration of saline water with cultural methods

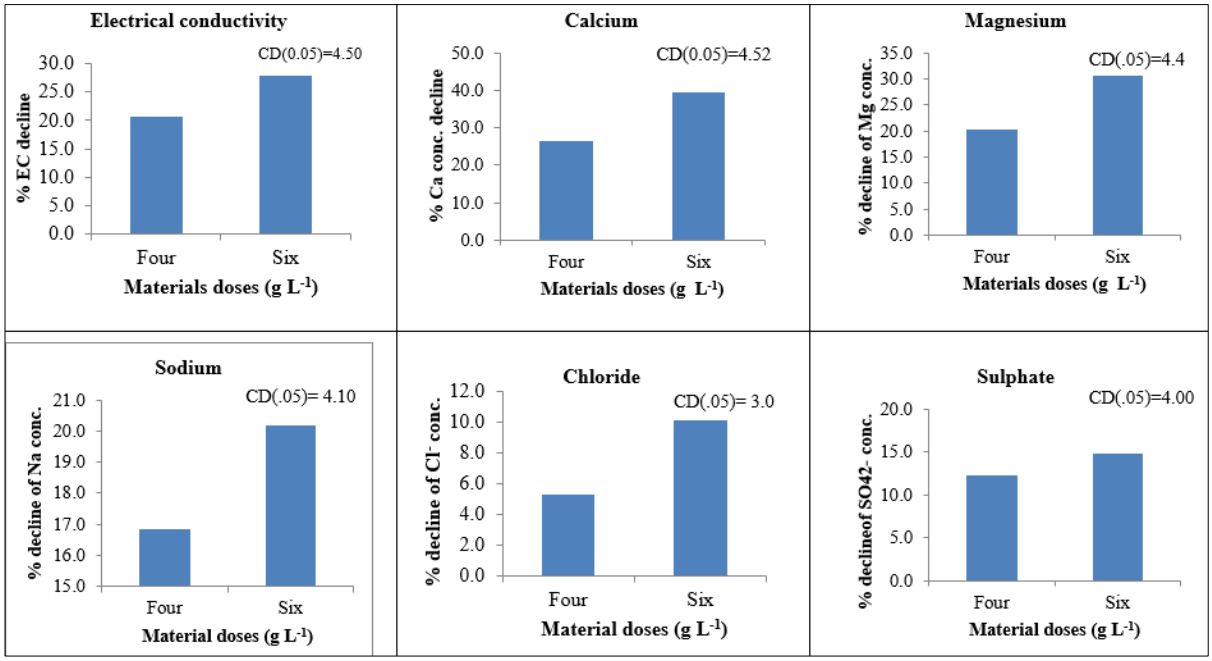

Fig 2: The materials dose effect on declining of EC, calcium, magnesium, sodium, chloride and sulphate ion concentration for amelioration of saline water with cultural methods

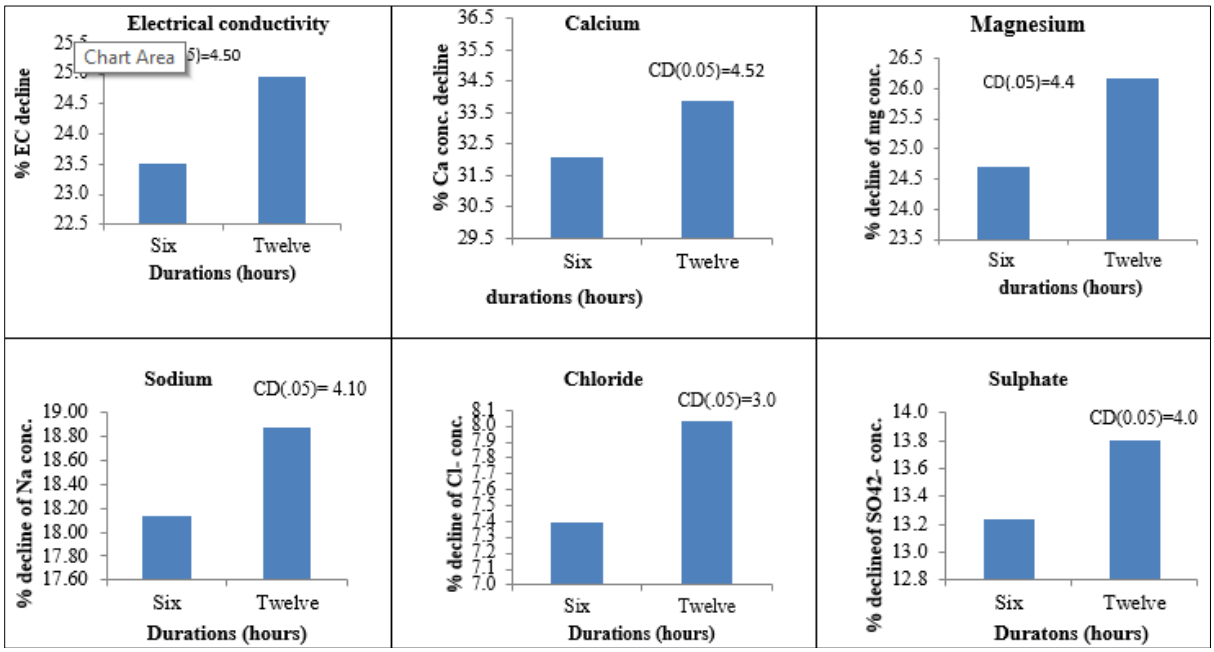

Fig 3: The incubation duration effect on declining of EC, calcium, magnesium, sodium, chloride and sulphate ion concentration for amelioration of saline water with cultural methods

The plethora of evidence was available against the wide range of cheap and low cost biosorbents use for removal of cations and anions pollutants from industrial waste waters (Gadd, 2009; Gupta *et al*. 2015) [9, 10]. Seperhr *et al*. 2013 has indirectly hinted the possible use of low cost pumice materials for salinity amelioration in spite of a very minor increase of EC in the treated water. The increase might be for sodium compound used for adsorbent modification otherwise it would have the declined EC value provided some acidic materials used for improvement of adsorbent properties. This is strongly supports the idea of adsorbent use for saline water amelioration. The declining efficiency with increase of saline water might be for increase of ion saturation in the surface of material with increase of saline water EC. Moreover, physical adsorption of ion could not develop multi-layer adsorption observed in the case heavy metals (Chakraborty *et al*. 2020) [4].

Effect of cultural methods on cationic concentration of saline waters

The initial calcium, magnesium and sodium concentration of saline water was given in the table. The ion concentrations significantly affected by the indigenous materials. The declining size effect was high for Amla stem powder with the reduction of 46.1% and 32.84% for calcium and magnesium (Table 3) and 4). However, The high sodium reduction was 18.27% observed in the Amla stem powder (M_1) and Muringa seed powder (M_2) and Tattamparai seeds powder (M_3) was equally effective as that of Amla stem powder in removal of sodium from saline water (Table 5). Since, the surface are and cation exchange capacity relatively higher than other materials could be the reason why the Amla stem powder had high adsorption of cations over others.

Table 3: Effect of indigenous materials on calcium concentration (meq L^{-1}) of saline water (Mean of three replications)

Treat. No.	Treatments	Calcium (meq L^{-1})					Mean
		M_1	**M_2**	**M_3**	**M_4**	**M_5**	
T_1	*S_1 water (2.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	1.05	1.14	1.27	1.35	1.56	1.27
		(43.24)	(38.65)	(31.62)	(27.30)	(15.68)	(31.30)
T_2	S_1 water (2.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	0.95	1.04	1.19	1.28	1.54	1.20
		(48.92)	(43.78)	(35.68)	(30.81)	(17.03)	(35.24)
T_3	S_1 water (2.0 dS m^{-1}) + Dose six (g L^{-1}) + 6 hrs incubation	0.54	0.68	0.88	1.00	1.32	0.88
		(70.81)	(63.24)	(52.70)	(45.95)	(28.92)	(52.32)
T_4	S_1 water (2.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	0.45	0.59	0.81	0.92	1.29	0.81
		(75.95)	(68.38)	(56.22)	(50.27)	(30.27)	(56.22)
T_5	S_2 water (4.0 dS m^{-1}) + Dose four (g L^{-1} + 6 hrs incubation	2.21	2.35	2.54	2.65	2.99	2.55
		(40.57)	(36.79)	(31.54)	(28.57)	(19.47)	(31.39)
T_6	S_2 water (4.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	2.10	2.26	2.47	2.58	2.94	2.47
		(43.27)	(39.22)	(33.42)	(30.59)	(20.77)	(33.46)
T_7	S_2 water (4.0 dS m^{-1}) + Dose six (g $L^{-1)}$ + 6 hrs incubation	1.46	1.66	1.97	2.14	2.63	1.97
		(60.78)	(55.39)	(47.04)	(42.32)	(29.18)	(46.94)
T_8	S_2 water (4.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	1.36	1.56	1.89	2.07	2.58	1.89
		(63.48)	(57.95)	(49.19)	(44.34)	(30.47)	(49.09)
T_9	S_3 water (6.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	3.90	4.04	4.26	4.38	4.76	4.27
		(29.82)	(27.21)	(23.24)	(21.17)	(14.31)	(23.15)
T_{10}	S_3 water (6.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	3.84	3.99	4.22	4.34	4.73	4.22
		(30.90)	(28.20)	(24.05)	(21.80)	(14.83)	(23.96)
T_{11}	S_3 water (6.0 dS m^{-1}) + Dose six (g L^{-1}) + 6 hrs incubation	3.17	3.38	3.71	3.88	4.41	3.71
		(42.88)	(39.19)	(33.24)	(30.18)	(20.58)	(33.22)
T_{12}	S_3 water (6.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	3.12	3.33	3.67	3.84	4.38	3.67
		(43.87)	(40.00)	(33.96)	(30.90)	(21.06)	(33.96)
T_{13}	S_4 water (8.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	6.67	6.82	7.06	7.19	7.57	7.06
		(20.60)	(18.81)	(15.95)	(14.46)	(9.89)	(15.94)
T_{14}	S_4 water (8.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	6.64	6.80	7.03	7.16	7.55	7.04
		(21.01)	(19.05)	(16.31)	(14.76)	(10.09)	(16.24)
T_{15}	S_4 water (8.0 dS m^{-1}) + Dose six (g $L^{-1)}$ + 6 hrs incubation	5.97	6.20	6.52	6.70	7.23	6.52
		(28.93)	(26.25)	(22.38)	(20.30)	(13.89)	(22.35)
T_{16}	S_4 water (8.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	5.93	6.16	6.50	6.67	7.21	6.49
		(29.40)	(26.73)	(22.68)	(20.65)	(14.11)	(22.72)
	Mean	3.08	3.25	3.50	3.63	4.04	
		(43.40)	(39.30)	(33.08)	(29.65)	(19.41)	
		Materials (M)		Treatments (T)		MXT	
	SEd	(3.76)		(4.50)		(6.25)	
	CD (5%)	(7.52)		(9.00)		(12.50)	
Saline waters	S1	S2		S3		S4	
Initial value (meq L^{-1})	1.85	3.71		5.55		8.40	

*Two gram dose of materials incubated in 2.0 dS m^{-1} saline water for 6 hours; () - per cent decline of calcium concentration; used for ANOVA test; M_1- Amla stem powder; M_2- Muringa seed powder; M_3- Seeds of Tattamparai; M_4- Lemon fruit powder; M_5- Coconut shell biochar

Table 4: Effect of indigenous materials on magnesium concentration (meq L^{-1}) of saline water (Mean of three replications)

Treat. No.	Treatments	Magnesium (meq L^{-1})					Mean
		M_1	**M_2**	**M_3**	**M_4**	**M_5**	
T_1	*S_1 water (2.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	0.85	0.90	0.97	0.99	1.11	0.96
		(37.41)	(33.70)	(28.52)	(26.67)	(17.96)	(28.85)
T_2	S_1 water (2.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	0.80	0.85	0.92	0.96	1.08	0.92
		(41.11)	(37.04)	(31.85)	(29.26)	(19.73)	(31.80)
T_3	S_1 water (2.0 dS m^{-1}) + Dose six (g L^{-1}) + 6 hrs incubation	0.59	0.67	0.76	0.81	0.99	0.76
		(56.30)	(50.74)	(44.07)	(40.00)	(27.02)	(43.63)
T_4	S_1 water (2.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	0.55	0.62	0.73	0.78	0.96	0.73
		(59.63)	(54.07)	(46.30)	(42.22)	(28.62)	(46.17)
T_5	S_2 water (4.0 dS m^{-1}) + Dose four (g L^{-1} + 6 hrs incubation	1.95	2.03	2.12	2.18	2.35	2.12
		(28.04)	(25.28)	(21.77)	(19.74)	(13.46)	(21.66)
T_6	S_2 water (4.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	1.91	1.98	2.09	2.14	2.32	2.09
		(29.70)	(27.03)	(23.06)	(21.03)	(14.26)	(23.02)
T_7	S_2 water (4.0 dS m^{-1}) + Dose six (g $L^{-1)}$ + 6 hrs incubation	1.50	1.60	1.77	1.85	2.13	1.77
		(44.83)	(41.14)	(34.69)	(31.73)	(21.52)	(34.78)
T_8	S_2 water (4.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	1.41	1.52	1.70	1.80	2.09	1.70
		(47.97)	(43.91)	(37.45)	(33.76)	(23.03)	(37.23)
T_9	S_3 water (6.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	3.17	3.24	3.37	3.43	3.63	3.37
		(21.73)	(20.00)	(16.91)	(15.31)	(10.43)	(16.88)
T_{10}	S_3 water (6.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	3.12	3.20	3.33	3.40	3.60	3.33
		(22.96)	(20.99)	(17.90)	(16.17)	(11.02)	(17.81)
T_{11}	S_3 water (6.0 dS m^{-1}) + Dose six (g L^{-1}) + 6 hrs incubation	2.75	2.86	3.04	3.13	3.42	3.04
		(32.22)	(29.51)	(24.94)	(22.72)	(15.47)	(24.97)

T_{12}	S_3 water (6.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	2.69	2.82	3.00	3.09	3.40	3.00
		(33.58)	(30.49)	(25.93)	(23.70)	(16.12)	(25.96)
T_{13}	S_4 water (8.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	5.68	5.76	5.89	5.95	6.16	5.89
		(14.07)	(12.86)	(10.97)	(9.98)	(6.75)	(10.93)
T_{14}	S_4 water (8.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	5.66	5.75	5.87	5.94	6.15	5.87
		(14.45)	(13.09)	(11.27)	(10.21)	(6.93)	(11.19)
T_{15}	S_4 water (8.0 dS m^{-1}) + Dose six (g $L^{-1)}$ + 6 hrs incubation	5.25	5.37	5.55	5.65	5.96	5.55
		(20.57)	(18.84)	(16.04)	(14.52)	(9.88)	(15.97)
T_{16}	S_4 water (8.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	5.23	5.36	5.53	5.64	5.95	5.54
		(20.88)	(18.91)	(16.34)	(14.67)	(10.02)	(16.16)
	Mean	2.69	2.78	2.91	2.98	3.21	
		(32.84)	(29.85)	(25.50)	(23.23)	(15.76)	
		Materials (M)		Treatments (T)		MXT	
	SEd	(3.10)		(3.95)		(5.40)	
	CD (5%)	(6.20)		(7.90)		(10.80)	
Saline waters	S1	S2		S3		S4	
Initial value (meq L^{-1})	1.35	2.71		4.05		6.61	

*Two gram dose of materials incubated in 2.0 dS m^{-1} saline water for 6 hours; () - per cent decline of magnesium concentration; used for Anova test; M_1- Amla stem powder; M_2- Muringa seed powder; M_3- Seeds of Tattamparai; M_4- Lemon fruit powder; M_5- Coconut shell biochar

Table 5: Effect of indigenous materials on sodium concentration (meq L^{-1}) of saline water (Mean of three replications)

Treat. No.	Treatments	Sodium (meq L^{-1})					Mean
		M_1	M_2	M_3	M_4	M_5	
T_1	*S_1 water (2.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	9.40	9.68	10.13	10.34	11.06	10.12
		(31.11)	(29.04)	(25.70)	(24.15)	(18.79)	(25.76)
T_2	S_1 water (2.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	9.10	9.40	9.89	10.13	10.92	9.89
		(33.33)	(31.11)	(27.48)	(25.70)	(19.85)	(27.50)
T_3	S_1 water (2.0 dS m^{-1}) + Dose six (g L^{-1}) + 6 hrs incubation	8.10	8.48	9.10	9.43	10.44	9.11
		(40.74)	(37.93)	(33.33)	(30.89)	(23.41)	(33.26)
T_4	S_1 water (2.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	7.80	8.25	8.88	9.22	10.30	8.89
		(42.96)	(39.63)	(34.96)	(32.44)	(24.47)	(34.89)
T_5	S_2 water (4.0 dS m^{-1}) + Dose four (g L^{-1} + 6 hrs incubation	21.58	21.98	22.61	22.94	23.97	22.62
		(20.60)	(19.13)	(16.81)	(15.60)	(11.80)	(16.79)
T_6	S_2 water (4.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	21.28	21.71	22.38	22.73	23.83	22.39
		(21.71)	(20.13)	(17.66)	(16.37)	(12.33)	(17.64)
T_7	S_2 water (4.0 dS m^{-1}) + Dose six (g $L^{-1)}$ + 6 hrs incubation	20.48	20.97	21.78	22.18	23.44	21.77
		(24.65)	(22.85)	(19.87)	(18.40)	(13.75)	(19.90)
T_8	S_2 water (4.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	20.18	20.68	21.55	21.97	23.30	21.54
		(25.75)	(23.91)	(20.71)	(19.17)	(14.28)	(20.77)
T_9	S_3 water (6.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	34.25	34.69	35.38	35.74	36.88	35.39
		(16.05)	(14.98)	(13.28)	(12.40)	(9.62)	(13.27)
T_{10}	S_3 water (6.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	34.10	34.55	35.28	35.64	36.80	35.27
		(16.42)	(15.32)	(13.53)	(12.65)	(9.79)	(13.54)
T_{11}	S_3 water (6.0 dS m^{-1}) + Dose six (g L^{-1}) + 6 hrs incubation	33.35	33.87	34.69	35.12	36.44	34.69
		(18.26)	(16.99)	(14.98)	(13.92)	(10.68)	(14.96)
T_{12}	S_3 water (6.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	33.20	33.72	34.58	35.02	36.37	34.58
		(18.63)	(17.35)	(15.25)	(14.17)	(10.85)	(15.25)
T_{13}	S_4 water (8.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	49.34	49.79	50.55	50.93	52.12	50.55
		(12.19)	(11.39)	(10.04)	(9.36)	(7.24)	(10.04)
T_{14}	S_4 water (8.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	49.24	49.69	50.48	50.86	52.07	50.47
		(12.37)	(11.57)	(10.16)	(9.49)	(7.33)	(10.18)
T_{15}	S_4 water (8.0 dS m^{-1}) + Dose six (g $L^{-1)}$ + 6 hrs incubation	48.59	49.09	49.97	50.41	51.76	49.96
		(13.53)	(12.64)	(11.07)	(10.29)	(7.88)	(11.08)
T_{16}	S_4 water (8.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	48.49	48.99	49.87	50.31	51.66	49.86
		(13.70)	(12.81)	(11.25)	(10.46)	(8.06)	(11.26)
	Mean	28.03	28.47	29.20	29.56	30.71	
		(22.63)	(21.05)	(18.51)	(17.22)	(13.13)	
		Materials (M)		Treatments (T)		MXT	
	SEd	(2.50)		(2.80)		(4.30)	
	CD (5%)	(5.00)		(5.60)		(8.60)	
Saline water	S1	S2		S3		S4	
Initial Value (meq L^{-1})	13.6	27.18		40.80		56.20	

*Two gram dose of materials incubated in 2.0 dS m^{-1} saline water for 6 hours; () - per cent decline of sodium concentration used for anova test; M_1- Amla stem powder; M_2- Muringa seed powder; M_3- Seeds of Tattamparai; M_4- Lemon fruit powder; M_5- Coconut shell biochar

The calcium, magnesium and sodium content of saline water decreased significantly with increase of saline water EC. The effect size was also decreased with increase of saline water EC sfor all the cations. The effect size was high for 2.0 dS m^{-1} saline water and they were 43.8%, 37.6% and 30.4% decline respectively for calcium, magnesium and sodium captions (Fig 1). The calcium, magnesium and sodium content of saline water decreased significantly with increase of material

dose. The reduction levels for doses were also decreased with increase of materials for all the cations. The decline level for 6 g L^{-1} dose was relatively when compared to 4 g L^{-1} and they were 39.6%, 30. 6% and 20.2% decline for calcium, magnesium and sodium (Fig 2). The calcium, magnesium and sodium content of saline water decrease were insignificant with increase of duration. Thus, the six minutes duration was being standardized for higher decline of cations from saline water. The concentration reduction was 32%, 24.7% and 18.1% respectively for calcium, magnesium and sodium cations (Fig 3).

For the interactive effect of saline water, materials and doses, it was observed that the treatment effect of 6 g L^{-1} for Amla stem wood powder and drumstick seed powder recorded high declining effect over others for calcium, magnesium and sodium and the higher effect were more than 54, 52 and 38.8% decline in the 2.0 dS m^{-1} saline water. The Amla wood and muringa seed powder of 6 g L^{-1} removed beyond 33%, and 30% calcium and magnesium respectively in the 6.0 dS m^{-1} saline water while beside these materials the Tattamparai seed powder was also equally effective observed more than 15% decline of sodium concentration.

There are many biosorbent showed wide range varaiation in adsorption of heavy metal as well calcium and magnesium ions (Chakraborty *et al*. 2020; Kumar and Sharma, 2017) [4]. It is fact as the increase of cations concentration with saline water EC was relatively much higher to the surface area available for adsorption that it showed a declining trend. It is in line with similar trend of cation removal with increase of concentration reported by many authors (Chakraborty *et al*. 2020; Bhatnagar *et al*. 2010) [4]. The materials showed preference in the order of their valence and size of ions that followed in the order of $Ca^{2+}>Mg^{2+}>Na^{2+}$ that the divalent removal efficiency was higher over the monovalent ions as supported by numerous evidences from literatures (de Quadros Melo *et al*. 2016) [7].

Effect of cultural methods on anionic concentration of saline waters

The chloride and sulphate concentration of saline water was significantly affected by the indigenous materials. The declining size effect was high for Amla stem powder with the reduction of 16.7% and 9.9% for sulphate and chloride (Table 6&7). This might be related to both protonation of functional groups and enhanced co-adsorption along with cations by electrostatic force in the Amla wood might be the reason why it also had relatively high removal of sulphate and chloride anions. Salama *et al*. 2016 [19] reported the surface properties and pH of solutes determines largely the chloride adsorption and the mineral oxidized activated carbon removed more than one one meq of chloride per gram. The sulphate preferred over chloride because of di valence preferred over mono valence as that of other biosorbent (Katal *et al*. 2012) [14].

Table 6: Effect of indigenous materials on chloride concentration (meq L^{-1}) of saline waters (Mean of three replications)

Treat. No.	Treatments	Chloride (meq L^{-1})					Mean
		M_1	M_2	M_3	M_4	M_5	
T_1	*S_1 water (2.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	9.00	9.04	9.15	9.20	9.36	9.15
		(7.22)	(6.80)	(5.67)	(5.15)	(3.46)	(5.66)
T_2	S_1 water (2.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	8.80	8.86	8.99	9.08	9.27	9.00
		(9.28)	(8.66)	(7.32)	(6.39)	(4.45)	(7.22)
T_3	S_1 water (2.0 dS m^{-1}) + Dose six (g L^{-1}) + 6 hrs incubation	7.80	7.95	8.23	8.35	8.79	8.22
		(19.59)	(18.04)	(15.15)	(13.92)	(9.40)	(15.22)
T_4	S_1 water (2.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	7.60	7.77	8.10	8.24	8.69	8.08
		(21.65)	(19.90)	(16.49)	(15.05)	(10.39)	(16.70)
T_5	S_2 water (4.0 dS m^{-1}) + Dose four (g L^{-1} + 6 hrs incubation	17.90	18.01	18.22	18.33	18.68	18.23
		(7.73)	(7.16)	(6.08)	(5.52)	(3.71)	(6.04)
T_6	S_2 water (4.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	17.70	17.83	18.06	18.19	18.58	18.07
		(8.76)	(8.09)	(6.91)	(6.24)	(4.21)	(6.84)
T_7	S_2 water (4.0 dS m^{-1}) + Dose six (g $L^{-1)}$ + 6 hrs incubation	16.70	16.92	17.28	17.49	18.10	17.30
		(13.92)	(12.78)	(10.93)	(9.85)	(6.68)	(10.83)
T_8	S_2 water (4.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	16.60	16.83	17.22	17.46	18.06	17.23
		(14.43)	(13.25)	(11.24)	(10.00)	(6.93)	(11.17)
T_9	S_3 water (6.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	27.40	27.53	27.78	27.89	28.28	27.78
		(5.84)	(5.40)	(4.54)	(4.16)	(2.80)	(4.55)
T_{10}	S_3 water (6.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	27.30	27.44	27.70	27.83	28.24	27.70
		(6.19)	(5.70)	(4.81)	(4.36)	(2.97)	(4.81)
T_{11}	S_3 water (6.0 dS m^{-1}) + Dose six (g L^{-1}) + 6 hrs incubation	26.30	26.53	26.92	27.12	27.76	26.93
		(9.62)	(8.83)	(7.49)	(6.80)	(4.62)	(7.47)
T_{12}	S_3 water (6.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	26.20	26.44	26.88	27.06	27.71	26.86
		(9.97)	(9.14)	(7.63)	(7.01)	(4.78)	(7.71)
T_{13}	S_4 water (8.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	37.00	37.14	37.39	37.53	37.94	37.40
		(4.64)	(4.28)	(3.63)	(3.27)	(2.23)	(3.61)
T_{14}	S_4 water (8.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	36.90	37.05	37.33	37.45	37.89	37.32
		(4.90)	(4.51)	(3.79)	(3.48)	(2.35)	(3.81)
T_{15}	S_4 water (8.0 dS m^{-1}) + Dose six (g $L^{-1)}$ + 6 hrs incubation	35.90	36.14	36.60	36.76	37.41	36.56
		(7.47)	(6.86)	(5.67)	(5.26)	(3.59)	(5.77)
T_{16}	S_4 water (8.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	35.80	36.06	36.50	36.68	37.36	36.48
		(7.73)	(7.06)	(5.93)	(5.46)	(3.71)	(5.98)
	Mean	22.18	22.35	22.65	22.79	23.26	
		(9.93)	(9.15)	(7.71)	(7.00)	(4.77)	
		Materials (M)		Treatments (T)		MXT	
	SEd	(1.75)		(2.00)		(2.85)	

	CD (5%)	(3.50)	(4.00)	(5.70)
Saline water	S1	S2	S3	S4
Initial Value (meq L^{-1})	9.70	19.40	29.10	38.8

*Two gram dose of materials incubated in 2.0 dS m^{-1} saline water for 6 hours; () - per cent decline of chloride concentration used for anova test; M_1- Amla stem powder; M_2- Muringa seed powder; M_3- Seeds of Tattamparai; M_4- Lemon fruit powder; M_5- Coconut shell biochar

Table 7: Effect of indigenous materials on sulphate concentration (meq L^{-1}) of saline waters (Mean of three replications)

Treat No.	Treatments	Sulphate (meq L^{-1})					Mean
		M_1	M_2	M_3	M_4	M_5	
T_1	*S_1 water (2.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	3.95	4.03	4.29	4.42	4.44	4.23
		(24.04)	(22.50)	(17.50)	(15.00)	(14.62)	(18.73)
T_2	S_1 water (2.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	3.90	3.98	4.23	4.35	4.39	4.17
		(25.00)	(23.46)	(18.65)	(16.35)	(15.58)	(19.81)
T_3	S_1 water (2.0 dS m^{-1}) + Dose six (g L^{-1}) + 6 hrs incubation	3.55	3.68	3.97	4.13	4.16	3.90
		(31.73)	(29.23)	(23.65)	(20.58)	(20.00)	(25.04)
T_4	S_1 water (2.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	3.45	3.60	3.89	4.05	4.08	3.81
		(33.65)	(30.77)	(25.19)	(22.12)	(21.54)	(26.65)
T_5	S_2 water (4.0 dS m^{-1}) + Dose four (g L^{-1} + 6 hrs incubation	8.80	8.88	9.13	9.27	9.24	9.06
		(15.38)	(14.62)	(12.21)	(10.87)	(11.15)	(12.85)
T_6	S_2 water (4.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	8.75	8.83	9.07	9.22	9.19	9.01
		(15.87)	(15.10)	(12.79)	(11.35)	(11.63)	(13.35)
T_7	S_2 water (4.0 dS m^{-1}) + Dose six (g $L^{-1)}$ + 6 hrs incubation	8.55	8.67	8.97	9.13	9.17	8.90
		(17.79)	(16.63)	(13.75)	(12.21)	(11.83)	(14.44)
T_8	S_2 water (4.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	8.49	8.61	8.92	9.08	9.13	8.85
		(18.37)	(17.21)	(14.23)	(12.69)	(12.21)	(14.94)
T_9	S_3 water (6.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	13.85	13.97	14.20	14.36	14.33	14.14
		(11.22)	(10.45)	(8.97)	(7.95)	(8.14)	(9.35)
T_{10}	S_3 water (6.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	13.82	13.94	14.15	14.33	14.30	14.11
		(11.41)	(10.64)	(9.29)	(8.14)	(8.33)	(9.56)
T_{11}	S_3 water (6.0 dS m^{-1}) + Dose six (g L^{-1}) + 6 hrs incubation	13.65	13.77	14.04	14.21	14.28	13.99
		(12.50)	(11.73)	(10.00)	(8.91)	(8.46)	(10.32)
T_{12}	S_3 water (6.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	13.60	13.72	14.00	14.17	14.24	13.95
		(12.82)	(12.05)	(10.26)	(9.17)	(8.72)	(10.60)
T_{13}	S_4 water (8.0 dS m^{-1}) + Dose four (g L^{-1}) + 6 hrs incubation	19.00	19.12	19.35	19.53	19.49	19.30
		(8.65)	(8.08)	(6.97)	(6.11)	(6.30)	(7.22)
T_{14}	S_4 water (8.0 dS m^{-1}) + Dose four (g L^{-1}) + 12 hrs incubation	18.97	19.10	19.30	19.49	19.46	19.26
		(8.80)	(8.17)	(7.21)	(6.30)	(6.44)	(7.38)
T_{15}	S_4 water (8.0 dS m^{-1}) + Dose six (g $L^{-1)}$ + 6 hrs incubation	18.75	18.94	19.19	19.38	19.43	19.14
		(9.86)	(8.94)	(7.74)	(6.83)	(6.59)	(7.99)
T_{16}	S_4 water (8.0 dS m^{-1}) + Dose six (g L^{-1}) + 12 hrs incubation	18.73	18.90	19.16	19.34	19.39	19.10
		(9.95)	(9.13)	(7.88)	(7.02)	(6.78)	(8.15)
	Mean	11.24	11.36	11.62	11.78	11.80	
		(16.69)	(15.54)	(12.89)	(11.35)	(11.14)	
		Materials (M)		Treatments (T)		MXT	
	SEd	(2.2)		(2.9)		(4.6)	
	CD (5%)	(4.5)		(6.00)		(9.20)	
Saline waters	S1	S2		S3		S4	
Initial value (meq L^{-1})	5.20	10.40		15.60		20.80	

*Two gram dose of materials incubated in 2.0 dS m^{-1} saline water for 6 hours; () - per cent decline of sulphate concentration used for anova test; M_1- Amla stem powder; M_2- Muringa seed powder; M_3- Seeds of Tattamparai; M_4- Lemon fruit powder; M_5- Coconut shell biochar

The chloride and sulphate content of saline water decreased significantly with increase of saline water EC. The effect size was also decreased with increase of saline water EC for both anions. The effect size was high for 2.0 dS m^{-1} saline water and they were 11.2% and 22.6% decline respectively for chloride and sulphate anions. The anion concentration of saline water decreased significantly with increase of material dose. The reduction levels for doses were also decreased with increase of materials. The decline level for 6 g L^{-1} dose was relatively when compared to 4 g L^{-1} and they were 10.1% and 14.8% decline for chloride and sulphate. Since, the concentration decline was not significant for incubation duration the six minutes duration was being optimized for higher decline. The concentration reduction was 7.2% and 13.2% respectively for chloride and sulphate concentration.

For the interactive effect of water, materials and dose, it was observed that the treatment effect of 6 g L^{-1} varied for indigenous materials and the Amla stem wood recorded high declining effect for chloride and sulphate over others and they were 20.6% and 32.7% in the 2.0 dS m^{-1} saline water. The Drumstick powder was on par with Amla wood powder in decreasing the sulphate content recorded 30.0% decline.

The electrostatic force from the positive charges and protonation of functional group and co-adsorption are the reported mechanism for sulphate while the positive charges derived from the protonation of functional group adsorbed the chloride due to electrostatic force are the reported mechanism for their removal from industrial waste saline water (Hong *et al*. 2017) [11]. The chloride expresses both osmotic and ion toxicity effect while the suphate is a secondary nutrient rarely expressed plant toxicity. However, the excessive amount reported to cause osmotic effect and reduce water uptake by crop need abatement before to be used for irrigation.

It is concluded from the findings that the saline water can be ameliorated for low to moderate level improvement of irrigation water quality at the source point by adapting the cultural methods. The Amla wood powder at the dose of 4 g L^{-1} for six hours duration can be recommended up to 8 dS m^{-1} saline water. Even though it is eco-friendly techniques but the amount residues availability for regular treating saline water for irrigation purpose is biggest challenge.

The rainfed crop is characterized with high salt tolerance and solely depends on the monsoon rainfall for crop irrigation. This will be a promising technology in a situation where the occurrence of monsoon rainfall failure at the critical stage of crop and the available underground water is highly saline nature needed amelioration before irrigation to crop. The treatment for one crop lifesaving irrigation appeared not much laborious comparing to treaing saline water for all saline water irrigation. It is not only going to save farmers from loss due to crop failure but it also ensures an improved crop yield and the livelihood of small and marginal famer under stress situation, where the agriculture is the main occupation. This findings motivates for further study on how the ameliorated saline water ranged between 0.5 to 8.0 dS m^{-1} interact with soils and eventually the crop response.

Acknowledgement

Help and support from Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University Tamil Nadu, Coimbatore and ICAR-National Institute of Abiotic Stress Management, Pune, Maharashtra and are acknowledged. First author acknowledges the guidance and financial support received for his PhD programme.

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