International Journal of
Environmental Sciences & Natural Resources
ISSN: 2572-1119

Juniper Publishers
key to the Researchers

Research Article
Volume 6 Issue 4 - September 2017
DIO : 10.19080/IJESNR.2017.06.555692

Int J Environ Sci Nat Res

Hydro Geochemical Processes of Evolution Of Ground Water In A Small Tropical Coral Island Of Amini, Union Territory Of Lakshadweep, India

Joji VS*

Scientist- D, Central Ground Water Board, Kerala, India

Submission: November 01, 2017; **Published:** November 16, 2017

***Corresponding author:** Joji VS, Scientist- D, Central Ground Water Board, Ministry of Water Resources, Govt. of India, Kerala Region, Kesavadaspuram, Thiruvananthapuram, Kerala, PIN-695004, Kerala, India, Tel: 09446361319 ; Email : jojivsdh@yahoo.com

Abstract

In the small tropical island of Amini ground water occurs under phreatic condition and is seen as a thin lens floating over the saline water. The coral sands and coral limestone act as principal aquifers. The depth of the wells varies from 1.6 to 5.5 mbgl and depth to the water table 1.20 to 4.80 mbgl. The ground water is generally alkaline and EC varies from 465 to 999 micromhos /cm at 25° C. The ground water is under Na^{+}-SO_4^{2-} type and shallow to deep meteoric percolation types and generally alkaline in nature. The factors affecting the quality of ground water are rainfall, tides, ground water recharge and draft, human and animal wastes, oil spills and fertilizers. Water samples collected from different parts of the island during pre-monsoon and post monsoon seasons. The water sample results of chemical analysis indicate that water type ranges from Ca-HCO3 (recharge type) to Ca-Mg-Cl type (reverse ion exchange water type). The hydrochemistry is mainly controlled by evaporation, partly influenced by water-rock interaction and aquifer materials. The evaporation process played major role in the evolution of water chemistry. The ground water in the study area is generally suitable irrigation for all types of soil.

Keywords: Atoll; Fresh water lens; Chloro alkali indices; Base exchange indices and Irrigation

Introduction

The Lakshadweep islands (LD islands) are a group of tiny coral islands, located in the Arabian Sea, about 400 km from the main land (southern tip of the Indian peninsula). They spread over a distance of 300 km, consists of 36 coral islands and a number of sunken banks, open coral reef and sand banks. These islands are typically a chain of low islands surrounding a shallow lagoon, consisting of large recent sediments on top of older coral limestone. Amini Island has a delicate ecosystem with very limited fresh water resources. Though the island receives high rainfall, lack of surface storage and the limited ground water storage capacity, where fresh water is occurring as a small lens floating over saline water, makes fresh water a precious commodity. High porosity of the aquifers allow mixing of freshwater with sea water and due to high population density, waste water gets mixed with the fresh water in the aquifer, make the management of the limited fresh water resources multifaceted.

The purpose of the study is to assess the evolution of ground water resources of the island and to know the hydro geological characteristics. The Small Island hydro geological and hydro chemical studies were carried out by many authors at international and regional levels. These include Nura Umar Kura et al. 2013 on Evaluation of Factors Influencing the Groundwater Chemistry in a Small Tropical Island of Malaysia [1], applied factor analysis tool to the hydro chemical data set of Manukan Island in order to extract the principal factors corresponding to the different sources of variation in the hydrochemistry, Belkhiria et al. 2012 studied geochemical evolution of groundwater in an alluvial aquifer in the case of El Eulma aquifer, East Algeria, [2] used application of multivariate statistical techniques in the assessment of groundwater quality in seawater intrusion area in Bafra Plain, Turkey [3] carried out assessment of groundwater quality for Veppanthattai taluk, Perambalur district, Tamil Nadu using Remote Sensing and GIS, [4] on fresh water - salt water relation, [5] Appraisal of groundwater resources in an island condition and many others. The present study is an attempt to highlight hydro geochemical processes of evolution groundwater in a small tropical coral island of Amini, Union Territory of Lakshadweep, India.

Study area

Amini Island is the sixth largest of the inhabited islands of the UT of Lakshadweep, with an area of 2.50 Km^2 and is elliptical in shape. Amini island is located between Kadmath and Kavarati (in the N-S direction) and between Agathi and Androth (in

the E-W direction) in a NE-SW alignment, about 11 km south of Kadmath island. It is about 58 km SW of Kiltan Island. It is 294 km from Mangalore, 324 km from Kozhikode and 407 km from Kochi. It is located between north latitudes 11^0 07' 00" and $11^0$08'00" and east longitude 72^0 44' 00" and 72^0 45' 00". The climate of Amini is similar to the climatic conditions of Kerala. March to May is the hottest period of the year. The temperature ranges from 25°C to 35°C and humidity ranging from 70 -76 per cent for most of the year. The average rainfall received is 1600 mm a year. Monsoon prevails here from 15th May to 15th September. During the monsoon time, boats are not allowed outside the lagoon because of the violent sea. The presence of the reef maintains calm at the lagoon.

The location map of LD islands including Amini Island is compiled (Figure 1) and various salient features of Amini are compiled (Table 1). The coral island is the work of minute sea organisms called coral polyps and they congregate in large colonies. When the organisms die, their skeletons, which are made of limestone, form big clusters, some of which rise above the water. Charles Darwin first described the different types of coral reef after his voyage by HMS Beagle among the Galapagos Isles in Pacific Ocean (Subsidence theory for the origin of coral reefs). In oceanic island fresh ground water occurs as a lens floating over saline water. The hydro dynamic balance of fresh and saline water determines the shape and movement of interface and may be controlled by some of the following factors viz. water table fluctuation due to diurnal tides, seasonal fluctuation of water table due to recharge or draft, dispersion and molecular diffusion. Due to these factors there is an alternate up and down movement of the interface.

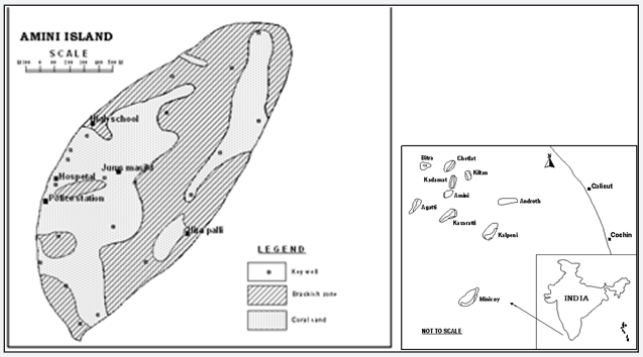

Figure 1: Location Map of Amini including other Lakshadweep Islands.

Table 1: Salient features of Amini islands.

#	Item	Detail
1	Latitudes	110 07' 00" and 11008'00" N
2	Longitudes	720 44' 00" and 720 45' 00"E
3	Total geographical area	2.50 sq.km
4	Population (as per 2011 census)	7661
5	Average annual rainfall	1660 mm
6	Annual range of temperature	24.00C - 31.10C
7	Major geological formation	Coral
8	Net ground water availability	0.55 MCM/Yr.
9	Stage of ground water development	63%
10	Lithology	Coralline sand and coral lime stones
11	Drainage	Surface water bodies and rivers generally absent or ephemeral.
12	Aquifer geometry	Not well defined by coral colonies & eustatic changes
13	Effect of over draft of ground water	Upconing of saline water from bottom
14	Effect of recharge	Fresh water lens expands & fractional rise in levels
15	Ground water estimation	By water balance or chloride budgeting
16	Ground water potential	Lower the per permeability, higher the potential
17	Drainage	Surface water bodies and rivers generally absent or are ephemeral.
18	Aquifer geometry	Not well defined by coral colonies & eustatic changes
19	Ground water	As lens, in hydraulic continuity with sea water
20	Effect of over draft of ground water	Upcoming of saline water from bottom
21	Effect of recharge	Fresh water lens expands &fractional rise in levels
22	Ground water estimation	By water balance or chloride budgeting

Materials and Methods

The base map of Amini and various layers were prepared by using Map Info 6.5 techniques and in the ground water resource of Amini has been computed based on the methodology recommended by the GEC 1997. The recharge to ground water lens = rain fall - interception - evapotranspiration and Ground water utilisation = Evapotranspiration + mixing + pumping +

How to cite this article: Joji VS. Hydro Geochemical Processes of Evolution Of Ground Water In A Small Tropical Coral Island Of Amini, Union Territory Of Lakshadweep, India. Int J Environ Sci Nat Res. 2017;6(4): 555692. DOI: 10.19080/IJESNR.2017.06.555692.

outflow, for water balance study monthly water budgeting or weekly water budgeting gives appropriate value of recharge. The main consumer of ground water is coconut palms because one coconut tree consumes 40 lpd and density of coconut trees is 25 000 - 35000 sq. km but draft through plant is slow, steady and spread uniformly.

The various hydro geological parameters collected during the field study and water level data observed during low and high tide. The pre-monsoon groundwater samples collected from shallow aquifers (dug wells) in polyethylene bottles and analysed for pH, EC, F^-, Cl^-, NO^{3-}, HCO^{3-}, $SO4^{2-}$, Ca^{2+}, Mg^{2+}, Na^+, and K^+ as per standard procedures (APHA, 1995) and the in-situ measurements of EC and pH were carried out by using EC and pH meters. The total dissolved solids were estimated by ionic calculation methods. The F^-, Cl^- and NO^{3-} ions were determined by ion selective electrode; HCO^{3-} by potentiometric titration; SO_4^{2-} by modified titration method after [6,7]; Ca^{2+} and Mg^{2+} in absorption mode while Na^+ and K^+ in emission mode of the atomic absorption spectrophotometer. The analytical results were tested for accuracy by calculating the Normalized Inorganic Charge Balance [8]. The analytical precision was such that the ion charge balance was little above ±5% for the samples. The quality of the analysis was ensured by standardization using blank, spike, and duplicate samples.

Results and Discussion

The major factors influence the hydrological characteristics of the island are climate, humidity, temperature, evapotranspiration, physiography, hydro geological aspects, soil, vegetation, population geomorphology, aquifer nature and human interference. The major hydrochemistry is discussed below.

Climate, humidity, temperature, evapotranspiration, physiography, hydro geological aspects, soil, vegetation, population, geomorphology, aquifer nature and human interference

The climate of a small island is one of the major influences on the availability of naturally occurring freshwater resources [9]. The rainfall distribution, quantity and its spatial and temporal variations and the evapotranspiration play an important role on the availability of the freshwater resources. The climate of Amini is similar to the climatic conditions of Kerala. March to May is the hottest period of the year. The temperature ranges from 25°C to 35°C and humidity ranging from 70 -76 per cent for most of the year. The average rainfall received is 1600 mm a year. Monsoon prevails here from 15th May to 15th September. The monsoon period raises temperature to the mercury level between 27-30 degrees. During the monsoon time, boats are not allowed outside the lagoon because of the violent sea. The presence of the reef maintains calm at the lagoon. The evapotranspiration is very high and most of the months except in high rainfall season it exceeds the rainfall making the water surplus on the negative side.

The entire LD islands lay on the northern edge of the 2500 km long North-South aligned submarine Lakshadweep-Chagos ridge. The island has coarse sandy soil of high porosity and permeability resulting in little or no surface runoff. The vegetation of LD islands consists of coconut trees, bushes and grasses. The Amini Island is a typical atoll and height of the land above msl is about 1-2 m and the coral sands and the coral limestone act as principal aquifers. The Ghyben-Herzberg relation determines the depth of the interface between fresh water and sea water. The water level data of monitoring wells in Amini Island reveals that depth of the wells ranges from 1.6 to 5.5 mbgl and the DTW ranges between 1.2 to 4.8 mbgl whereas diurnal fluctuation in water level due to tides is in the range of 0 to 80 cms. The climate water balance method of recharge estimation widely used for estimating the recharge on small islands Falkland 1992. Human activities influence both the availability of freshwater and water quality.

Hydro geochemical processes

The hydro geochemical processes of ground water and its evolution have been examined. The groundwater of different geological horizons can be classified depending upon their ionic strength of select anions and [10] categorized groundwater based on the meq/l content of Cl^-, SO_4^{2-}, and HCO^{3-}. The water is Normal chloride type if Cl^- is <15 meq/l, Normal sulphate type if SO_4^{2-} is <6 meq/l and Normal bicarbonate type if HCO^{3-} varies between 2 and 7 meq/l. Distribution of groundwater samples based on the Soltan's classification has indicated that majority of the samples are of Normal chloride type, followed by Normal bicarbonate type (values rounded off) and concentration of salts in natural waters depend on the geology, environment, and movement of water [11,12].

The base exchange indices, r1(r1 = Na+ – Cl–/ SO_4^{2-} meq/l) and r2 (r2 = K+ + Na+ – Cl– SO_4^{2-} meq/l) after [13] could be applied for the further classification of groundwater. The groundwater can be grouped as Na+ - HCO3- type if r1 > 1 and Na+- SO_4^- type with r1 < 1; r2 < 1- groundwater is of deep meteoric percolation type and >1, shallow meteoric percolation type. The groundwater of the area comes Na+- SO4 – type type and deep meteoric percolation type except a few one which is deep meteoric percolation type, chemical analysis data of ground water and other details are compiled (Tables 2 & 3). Hydro chemical evolution study based on Na^+ / Cl^- molar ratio Na^+ / Cl^- molar ratio will be 1 if halite dissolution is responsible for sodium dominance in groundwater and >1 if Na^+ is released from silicate weathering process [14]. The Na^+ / Cl^- molar ratio is <1 in many samples of the season, indicating that halite dissolution was the primary process responsible for the release of Na^+ into the groundwater.

Hydro chemical facies

The groundwater is further evaluated to determine its facies by plotting the percentages of select chemical constituents in Modified Piper diagram [15]. The plots for the PRS season

How to cite this article: Joji VS. Hydro Geochemical Processes of Evolution Of Ground Water In A Small Tropical Coral Island Of Amini, Union Territory Of Lakshadweep, India. Int J Environ Sci Nat Res. 2017;6(4): 555692. DOI: 10.19080/IJESNR.2017.06.555692.

indicated distribution within the fields 5 and 6 of the Chadha's diagram (Figures 2a & 2b) and are characterized by alkaline earths and weak acidic anions exceed both alkali metals and strong acidic anions, respectively i.e (Ca+Mg)+ (CO_3+HCO_3)> (Na +K) +(Cl+SO_4) and the sample at Ammini - Sidiqui Palli with alkaline earths exceed alkali metals and strong acidic anions exceed weak acidic anions ie (Ca+Mg)>(Na+K)>(Cl+SO_4)>(CO_3+HCO_3). All the water samples of PSM are falling under field 5. All the samples except Ammini - Sidiqui Palli falling under Sub-field I and are Ca-HCO_3 Type / recharge type water but that of Ammini - Sidiqui Palli falling under sub-field II Sub-field II and is Ca-Mg-Cl type, reverse ion exchange type. The plots also suggest that among cations Ca+ and Na+ and anions HCO_3^- and Cl – dominate the ionic concentration in groundwater.

Table 2: Chemical analysis data of ground water in Amini.

Pre monsoon (PRM) 2010																	
#	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F	SAR	RSC	TDS	%Na
1	8.12	492	244	58	24	6.7	0.3	0	317	13	10	0.57	1.47	0.19	0.32	344	5.78
2	8.12	657	315	80	28	14	1.1	0	397	32	20	3.4	0.75	0.34	0.20	460	9.17
3	8.14	822	330	66	40	34	2.9	0	409	71	25	5.3	0.9	0.81	0.11	575	19.06
4	8.1	999	335	60	45	67	4.1	0	287	167	31	11	0.64	1.59	-2.00	699	31.05
5	8.23	741	295	52	40	30	1.5	0	354	75	21	4.8	0.68	0.76	-0.09	519	18.56
Min	8.10	492	244	52	24	7	0	0	287	13	10	1	0.64				
Max	8.23	999	335	80	45	67	4	0	409	167	31	11	1.47				
Mean	8.14	742	304	63	35	30	2	0	353	72	21	5	0.89				
SD	0.05	189	37	11	9	23	2	0	52	59	8	4	0.34				
BIS DWS - MDL	8.50	750	300	75	30	NR	NR	NR	500	250	200	45	1.00				
Pre monsoon (PSM) 2010																	
#	pH	EC	TH	Ca	Mg	Na	K	CO3	HCO3	Cl	SO4	NO3	F	SAR	RSC	TDS	%Na
1	8.04	465	268	70	23	7.4	0.5	0	342	11	7.1	0.7	1.3	0.20	0.21	326	5.84
2	8.04	555	285	74	24	16	0.6	0	372	21	14	1.5	0.2	0.41	0.42	389	11.13
3	8.24	835	340	62	45	52	1.1	0	433	75	26	1.1	0.45	1.23	0.30	585	25.18
4	7.68	572	195	42	22	38	5.1	0	214	60	19	12	0.44	1.18	-0.40	400	31.31
5	7.79	725	335	88	28	23	0.6	0	451	36	15	2	0.44	0.55	0.69	508	13.15
Min	7.68	465	195	42	22	7	1	0	214	11	7	1	0.20				
Max	8.24	835	340	88	45	52	5	0	451	75	26	12	1.30				
Mean	7.96	630	285	67	28	27	2	0	362	41	16	3	0.57				
SD	0.22	148	59	17	10	18	2	0	94	27	7	5	0.42				
BIS DWS - MDL	8.50	750	300	75	30	NR	NR	NR	500	250	200	45	1.00				

Table 3: Different parameters of Pre and Post monsoon water samples.

Well Nos	Cl–	SO4 2–	HCO3 –	Base exchange index, (r1)	Base exchange index, (r2)	Na/Cl	Ca/Mg	Chloroalkali indices for cations, CAI-1	Chloroalkali indices for anions, CAI-2
Pre monsoon, 2010 (PRM)									
1	0.37	0.21	5.20	-1.5	-0.3	0.52	1.47	0.18	0.01
2	0.90	0.42	6.51	-1.6	-0.6	0.44	1.74	0.29	0.04
3	2.00	0.52	6.70	-2.4	-0.9	0.48	1.00	0.22	0.06
4	4.71	0.65	4.70	-4.4	-2.6	0.40	0.81	0.36	0.31
5	2.12	0.44	5.80	-3.5	-1.8	0.40	0.79	0.37	0.12

How to cite this article: Joji VS. Hydro Geochemical Processes of Evolution Of Ground Water In A Small Tropical Coral Island Of Amini, Union Territory Of Lakshadweep, India. Int J Environ Sci Nat Res. 2017;6(4): 555692. DOI: 10.19080/IJESNR.2017.06.555692.

Mean	2.02	0.45	5.78	-2.66	-1.24	0.69	0.74	0.29	0.11
Min	0.37	0.21	4.70	-4.38	-2.62	0.62	0.51	0.18	0.01
Max	4.71	0.65	6.70	-1.47	-0.33	0.79	6.58	0.37	0.31
SD	1.68	0.16	0.85	1.27	0.94	0.08	1.26	0.08	0.12
Post monsoon, 2010 (PSM)									
1	0.31	0.15	5.61	-1.78	0.16	0.67	1.85	-0.08	0.00
2	0.59	0.29	6.10	-1.34	0.41	0.76	1.87	-0.20	-0.02
3	2.12	0.54	7.10	-1.64	0.32	0.69	0.84	-0.08	-0.02
4	1.69	0.40	3.51	-2.62	0.23	0.63	1.16	-0.05	-0.02
5	1.02	0.31	7.39	-2.25	0.00	0.64	1.91	0.00	0.00
Mean	1.15	0.34	5.94	-1.93	0.22	0.68	1.53	-0.08	-0.01
Min	0.31	0.15	3.51	-2.62	0.00	0.63	0.84	-0.20	-0.02
Max	2.12	0.54	7.39	-1.34	0.41	0.76	1.91	0.00	0.00
SD	0.75	0.14	1.54	0.51	0.16	0.05	0.50	0.07	0.01

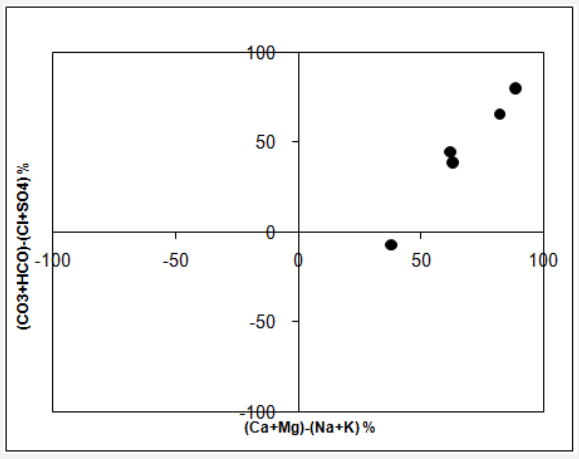

Figure 2a : Modified Piper Diagram-PRM 2010.

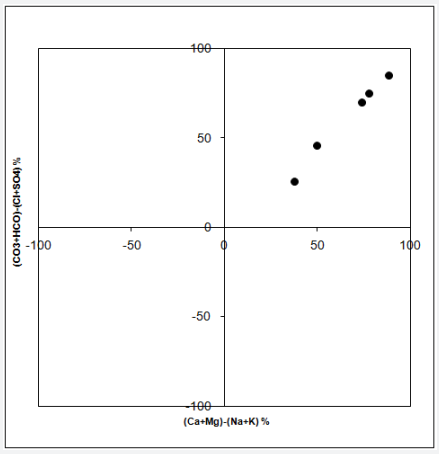

Figure 2b : Modified Piper Diagram-PSM 2010.

Hydro geochemical evaluation

The high sodium content among cations in the groundwater for the period could be due to halite dissolution which was further enhanced by evaporation and/or evapotranspiration processes. The Na^+ /Cl^- molar ratio will be 1 if halite dissolution is responsible for sodium dominance in groundwater and >1 if Na+ is released from silicate weathering process Meybeck 1987. The Na^+ / Cl^- molar ratio is >1 in the samples of water can only evolve to brine rich in NaCl if it encounters highly soluble chloride minerals, typically associated with evaporative deposits / evaporates [16]. As all the groundwater samples of the season with Na^+ /Cl^- molar ratio less than one or nearer to one, halite dissolution is responsible for sodium dominance in groundwater of the small coral island of Amini, Union Territory of Lakshadweep.

Evolution of groundwater

[17] plots, in which TDS vs Na^+ /(Na^+ +Ca^{2+}) for cations and TDS vs Cl^- /(Cl^- + HCO^{3-}) for anion were plotted to know evolution process of the groundwater and the influence of host rock on ground water chemistry. It is revealed that the samples, occupied the evaporation dominance field. The rock water interaction played minimum role in the evolution of water chemistry, which was dominated by evaporation process during PRM and PSM. The geological location is one of the most important factors affecting the groundwater quality [18].

Chloro alkali indices

The role of aquifer material in the evolution of groundwater chemical composition has been examined by determining the chloro alkali indices for cations (CAI-1) and anions (CAI-2). The CAI-1 [Cl^- – (Na^+ + K^+)]Cl^- and CAI-2 [Cl^- – (Na^+ + K^+)/(SO_4^{2-} + HCO_3^- + CO_3^- + NO^-)], developed by [19], relate the ion exchange process between ground water and aquifer material. The CAI-1 and CAI-2 are negative in the samples indicating the ion exchange between Na^+ -K^+ in water and Ca^{2+} -Mg^{2+} in rocks [20]. It is imperative to understand the modifications in water chemistry during its movement and residency time for better evaluation of the hydrochemistry of any area more so when different geological formations are involved in a watershed or river basin [21]. As CAI-1 and CAI-2 are negative in the

How to cite this article: Joji VS. Hydro Geochemical Processes of Evolution Of Ground Water In A Small Tropical Coral Island Of Amini, Union Territory Of Lakshadweep, India. Int J Environ Sci Nat Res. 2017;6(4): 555692. DOI: 10.19080/IJESNR.2017.06.555692.

samples of PSM indicating the ion exchange predominance in the study area during post-monsoon and positive values during PRM shown lesser role of ion exchange during pre-monsoon.

Irrigation Suitability: The irrigation suitability of ground water has been attempted based on the study of electrical conductivity (EC), Sodium Adsorption Ratio (SAR), Percent Sodium (% Na), Permeability index (PI), Kelley's Index (KI), Soluble Sodium Percentage (SSP) and Magnesium Ratio (MR) methodologies (Table 4) and Wilcox classification of irrigation water and U S Salinity diagram for irrigation Water, methodology and analytical results are compiled (Table 5).

Table 4: Methodology adopted for computations of Irrigation Suitability.

Aspects	Formula	Range	Classification	Reference
EC, µS/cm at 25oC		<250	Excellent	Raghunath, 1987
		250-750	Good	
		750-2000	Permissible	
		2000-3000	Doubtful	
		>3000	Unsuitable	
SAR	SAR = Na / √ (Ca+Mg) / 2	<10	Excellent	Richards,1954
		10–18	Good	
		18–26	Doubtful	
		>26	Unsuitable	
%Na	%Na = ((Na+K) / (Ca+Mg+Na+K))*100	<20	Excellent	Raghunath,1987
		20–40	Good	
		40–60	Permissible	
		60-80	Doubtful	
		> 80	Unsuitable	
PI	PI = ((Na+ (√HCO3) / (Ca+Mg+Na))*100	>75	Class I	Doneen,1964
		25- 75	Class II	
		<25	Class III	
KI	KI= Na/Ca+Mg	>	Unsuitable	Kelley,1940
		1-2	Poor	
		< 1	Suitable	
SSP	SSP= Na*100/ Ca+Mg+Na	>50		
	Unsuitable	Khodapanah et al, 2009		
		< 50	suitable	
Mg Ratio	MR = (Mg*100) / (Ca+Mg)	>50		
	Unsuitable	Lloyd and Heathcote, 1985		
		< 50	suitable	

Table 5: Quality parameters of PRM & PSM water samples determined for Irrigation Suitability XC.

#	Location	SAR	%Na	KI	P I	SSP	EC , µ S/cm	Mg Ratio
PRM water samples, 2010								
1	Ammini - UJRA Palli	0.19	5.78	0.06	49.76	5.64	492	40.51
2	Ammini - Maidanul Islam Madrassa	0.34	9.17	0.10	45.71	8.81	657	36.55
3	Ammini - Nercha Palli	0.81	19.06	0.22	50.41	18.32	822	49.94

How to cite this article: Joji VS. Hydro Geochemical Processes of Evolution Of Ground Water In A Small Tropical Coral Island Of Amini, Union Territory Of Lakshadweep, India. Int J Environ Sci Nat Res. 2017;6(4): 555692. DOI: 10.19080/IJESNR.2017.06.555692.

4	Ammini - Sidiqui Palli	1.59	31.05	0.43	52.85	30.29	999	55.24
5	Ammini - Homeo Hospital	0.76	18.56	0.22	51.60	18.13	741	55.87
Mean	0.74	16.72	0.21	50.07	16	742	48	
Min	0.19	5.78	0.06	45.71	6	492	37	
Max	1.59	31.05	0.43	52.85	30	999	56	
SD	0.55	9.88	0.15	2.71	10	189	9	
PSM water samples, 2010								
1	Ammini - UJRA Palli	0.20	5.84	0.06	47.07	5.63	465	35.10
2	Ammini - Maidanul Islam Madrassa	0.41	11.13	0.12	49.68	10.92	555	34.80
3	Ammini - Nercha Palli	1.23	25.18	0.33	54.34	24.94	835	54.43
4	Ammini - Sidiqui Palli	1.18	31.31	0.42	63.37	29.70	572	46.30
5	Ammini - Homeo Hospital	0.55	13.15	0.15	48.27	12.98	725	34.37
Mean	0.71	17.32	0.22	52.55	17	630	41	
Min	0.20	5.84	0.06	47.07	6	465	34	
Max	1.23	31.31	0.42	63.37	30	835	54	
SD	0.47	10.55	0.15	6.65	10	148	9	

Electrical conductivity: The EC is a measure of salinity hazard to crops and classified into five major types, as per Raghunath 1987 and that the samples in the study area are under excellent, good, permissible and doubtful categories.

Sodium Absorption Ratio, SAR: The sodium alkali hazard or Sodium Absorption Ratio (SAR) of water is an indicator of sodium hazard in irrigation water Gholami and Srikantaswamy 2009. As per Richard 1954, the computed SAR values show that all the samples are excellent.

Percent Sodium (% Na): The % Na is used to assess the ground water quality, because a higher level of sodium in irrigation water may increase the exchange of sodium content of irrigated soil and affect soil permeability, structure and create toxic condition for plants [22,23] and Todd 1980. Based on the relative proportions of cation concentration, samples come under excellent to good categories and can be used for irrigation on almost all types of soil.

Permeability index, PI: Doneen 1964 has classified the irrigation water quality into three classes based on permeability-class I, II and III and all the samples come under Class II and suitable for irrigation in all types of soil.

Kelley's Index, KI: Kelley 1940 and Paliwal 1967 proposed the suitability of irrigation water quality based on the sodium concentration against calcium and magnesium. The water is suitable for irrigation if KI value is <1; water with KI value of >1 is considered as of poor quality for irrigation and >2 KI makes the water unsuitable for irrigation. Both cation exchange and reverse ion exchange are encouraged by aquifer materials and land use practices, in waterlogged area, marshy/swampy land, creek, mud/tidal flat represented by Montmorillonite clays, which lead to the release of Na or Ca into groundwater and adsorption of Ca or Na, respectively Alison et al. 1992. In all samples KI values are below 1 indicating the water in the study area is suitable for irrigation.

Soluble Sodium Percentage, SSP: Water with less than or equal to 50 SSP value is of good quality and more than 50 is not suitable for irrigation as permeability will be very low [24-26]. In the study area all the water samples with SSP values less than 50.

Magnesium Ratio MR: Water with less than or equal to 50 MR value is of good quality and >50 is considered unsuitable for irrigation Lloyd and Heathcote et al. 1985. In the study area majority of the water samples except one water sample with MR values less than 50.

Conclusion

Hydrogeochemical processes of evolution of groundwater in in the small coral island of Amini, Union Territory of Lakshadweep, India has been examined. The Amini island is of coral origin (a

How to cite this article: Joji VS. Hydro Geochemical Processes of Evolution Of Ground Water In A Small Tropical Coral Island Of Amini, Union Territory Of Lakshadweep, India. Int J Environ Sci Nat Res. 2017;6(4): 555692. DOI: 10.19080/IJESNR.2017.06.555692.

typical atoll) and ground water occurs under phreatic condition floats as thin lens over saline water and is abstracted mainly by open dug wells. The DWT in the island varies from 1.20 to 4.80 mbgl and depth of the wells varies from less than two meters to about 5.5 mbgl and is controlled by tides. The ground water in the island is generally alkaline ranges from 465 to 999 micromhos / cm at 25 ^{o} C. The factors affecting the quality are rainfall, tides, ground water recharge and draft, human and animal wastes, oil spills and fertilizers. The groundwater samples of different areas are of Na- SO_4 Type and deep meteoric percolation type. The ground water in the area is mainly Ca-HCO_3 type / recharge type water and Ca-Mg-Cl type (reverse ion exchange water type. The hydrochemistry is mainly controlled by evaporation, followed by water-rock interaction and aquifer material.

Acknowledgement

The author is grateful to Sh. V Kunhambu, Regional Director, Rajiv Gandhi National Ground Water Training and Research Institute, Govt. of India, Raipur for all the encouragement given during the course of the work. Thanks are also due to Kumari Himaganga Joji, daughter of the author for the data entry and editing of the manuscript.

References

1. Aris AZ, Abdullah MH, Ahmed A, Woong KK (2007) Controlling factors of groundwater hydrochemistry in a small island's aquifer. International Journal of Environmental Science & Technology 4 (4): 441-450.
2. Arslan H (2013) Application of multivariate statistical techniques in the assessment of groundwater quality in seawater intrusion area in Bafra Plain, Turkey. Environ Monit Assess 185: 2439-2452.
3. Kumar G (2015) Assessment of groundwater quality for Veppanthattai taluk, Perambalur district, Tamil Nadu using Remote Sensing and GIS techniques. International Journal of Recent Scientific Research 6: 3142-3146.
4. Barker JA (1984) 'Freshwater-Saltwater relation' workshop on water resources of small islands. Suva, Fuji, Japan.
5. Mondal NCVS, Singha, Sarwade DV, Nandakumar MV (2009) Appraisal of groundwater resources in an island condition. J Earth Syst Sci 118(3): 217-229.
6. Fritz JS, Yamamura SS (1955) Rapid micro titration of sulphate. Anal. Chem. 27:1461-1464.
7. Haartz JC, Eller PM, Hornung RW (1979) Critical parameters in barium per chlorate, Thorin Titration of Sulphate. Anal Chem 5(13): 2293-2295.
8. Huh Y, Tsoi MY, Zaitiser A, Edward JN (1998) The fluvial geochemistry of the river of Eastern Siberia 1. Tributaries of Lena river drainage the sedimentation platform of the Siberia Craton. Geochimica et Cosmochimicha Acta 62(10): 1657-1676.
9. UNESCO (1991) Hydrology and water resources of Small Island. A Practical Guide Studies and Reports on Hydrology no 49 UNESCO, Paris.
10. Soltan ME (1998) Characterization classification and evaluation of some groundwater samples in Upper Egypt. Chemos 37: 735-747
11. Raghunath HM (1982) Groundwater New Delhi, Wiley, pp. 456.
12. Gopinath G, Seralathan P (2006) Chemistry of ground water in the laterite formation of Muvatturpuzha river basin, Kerala. Journal of the Geological Society of India 68: 705-714.
13. Soltan ME (1999) Evaluation of groundwater quality in Dakhla Oasis. Egyptian Western Desert Environmental Monitoring and Assessment 57(2):157-168.
14. Meybeck M (1987) Global chemical weathering of surficial rocks estimated from river dissolved leads. American Journal of Science 287: 401-428.
15. Chadha DK (1999) A proposed new diagram for geochemical classification of Natural waters and Interpretation of chemical data. Hydrogeology Journal 7(5): 431-439.
16. Gosselin C D, Edwin H F, Flowerday C (2003) The complex Dakota aquifer: Managing groundwater in Nebraska.
17. Gibbs RJ (1970) Mechanisms controlling World's Water chemistry. Science 170(3962):1088-1090.
18. Beck B F, Asmussen L, Leonard RS (1985) Relationship of geology, physiography, agricultural land use and groundwater quality in south-west Georgia. Ground Water, GRWAAP 23(5): 627-634.
19. Schoeller H (1967) Qualitative evaluation of groundwater resources In Methods and techniques of groundwater investigation and development. Water Research 33: 44-52.
20. McIntosh JC, Walter LM (2006) Palaeowater in Silurian-Devonian carbonate aquifers: Geochemical evolution of groundwater in the Great Lakes region since Late Pleistocene. Geochimica Cosmochimica Acta 70: 2454-2479.
21. Sastry JCV (1994) Groundwater chemical quality in river basins. hydrogeochemical facies and hydrogeochemical modeling in Lecture notes-refresher course conducted by School of Earth Sciences Bharathidasan University, Thiruchirapalli, Tamilnadu, India.
22. Bangar KS, Tiwari SC, Vermaandu SK, Khandkar UR (2008) Quality of groundwater used for irrigation in Ujjain district of Madhya Pradesh, India. Journal of Environmental Science Engineering 50(3): 179-186.
23. Durfer CM, Backer E (1964) Public water supplies of the three largest cities in the U.S, USGS Water supply paper No 1812 pp. 364.
24. American Public Health Association (1995) Standard methods for the examination of water and waste water 19th (edn). Washington DC APHA.
25. Belkhiria L, Mounib L, Boudoukha A (2012) Geochemical evolution of groundwater in an alluvial aquifer, Case of El Eulma aquifer, East Algeria. J Afr Earth Sci 66: 46-55.
26. Nura Umar Kura, Mohammad Firuz Ramli, Wan Nur Azmin Sulaiman, Shaharin Ibrahim, Ahmad Zaharin Aris et al. (2013) Evaluation of Factors Influencing the Groundwater Chemistry in a Small Tropical Island of Malaysia. Int J Environ Res Public Health 10(5): 1861-1881.

How to cite this article: Joji VS. Hydro Geochemical Processes of Evolution Of Ground Water In A Small Tropical Coral Island Of Amini, Union Territory Of Lakshadweep, India. Int J Environ Sci Nat Res. 2017;6(4): 555692. DOI: 10.19080/IJESNR.2017.06.555692.

DOI: 10.19080/IJESNR.2017.06.555692

How to cite this article: Joji VS. Hydro Geochemical Processes of Evolution Of Ground Water In A Small Tropical Coral Island Of Amini, Union Territory Of Lakshadweep, India. Int J Environ Sci Nat Res. 2017;6(4): 555692. DOI: 10.19080/IJESNR.2017.06.555692.