P: ISSN No. 2231-0045 RNI No. UPBIL/2012/55438 VOL.-7, ISSUE-1, August-2018

E: ISSN No. 2349-9435 Periodic Research

Degradation in Surface Water Quality Due to Opencast Mining around Kolayat, Bikaner District, North-Western Rajasthan, India

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Abstract

The district of Bikaner lies in North-Western part of Rajasthan which is a central part of Great Indian Thar desert and is well popular for its rich deposits of nonmetallic minerals like lignite, clays, fuller's earth, siliceous earth, gypsum, bentonite, silica sand, limestone and sandstone etc. throughout country and abroad. The endowed deposits of minerals in vicinity of Bikaner district are very much source raw material for many industries. Mining and its related activities are sources of employments for the local people and the socio-economic conditions are getting better in parts of Bikaner district. Opencast Clay, lignite, fuller's earth mining activities are in progress around Kolayat about 40 km south west of Bikaner district headquarter. The present study reveals that the concentration of certain chemical components like pH, EC,TDS, TSS, Chloride, nitrates, Bi-cabonates, Hardness, in surface water bodies from clay mine areas around Kolayat are high compared to that from non-clay mine pit areas. The colour of surface water bodies are also getting change in the study area due to mining activities. The resultant analyzed value are high according to Indian standard specification of drinking water i.e. IS 10500: 2012. High incidence of bacterial contamination is observed in dug well waters, which stresses the need for proper treatment prior to human consumption. Local people of Kolayat are using surface water for drinking as well as domestic purposes. Since Kolayat lake (Kapil sarovar) have asthetic value where a famous annual fair is held and thousands of pilgrims dips in holy water of kapi lsarovar. Degradation in surface water quality around Kolayat region of Bikaner district due to mining and other related activities, there is severe need to make remediation, sustainable development and managements.

Keywords: Opencast Mining, Surface Water Quality.

Introduction

The district of Bikaner lies in north western part of Rajasthan which is a central part of Great Indian Thar desert and is well popular for its rich deposits of nonmetallic minerals like lignite, clays, fullar's earth, siliceous earth, gypsum, bentonite, silica sand, limestone and sandstone etc. throughout country and abroad. The endowed deposits of minerals in vicinity of Bikaner district are very much source raw material for many industries. Mining and its related activities are sources of employments for the local people and the socio-economic conditions are getting better in parts of Bikaner district. Clay is the important source material for the ceramic industries. There are many industries of plaster of peris, fertilizers and ceramics based on gypsum and clays. The adoption of unplanned and traditional mining methods are continuously deteriorate the surrounding by causing disturbing topographic features, drainage pattern, destruction of vegetations, adversely affecting the quality of surface and underground water etc. Water is a prime natural resource which is a basic need of human being and a precious national asset and hence it is strongly required to make suitable planning, development and management of it (*Yadav et. al.*, (2013). Mining activities are also enhancing pollution of air, land and water in the area. The characteristics of mined land of clay, lignite, limestone , fuller's earth, gypsum and sandstone mining in area are very much untolarable. The mined out land due to indiscriminate quarrying of minerals in the area getting the undulating, barren, unfertile, dumped and spoils. Ditches and unorganized trenches are common. Dust generated by quarrying minerals is responsible for several severe health problems. So to overcome the land degradation in the area there is plenty of needs to rehabilitation of mined land by using proper rain water harvesting, conserve the water resources, conserve the top soil and by growing more and more protective and productive trees, shrubs and grasses which are well adapted to the region and favourable climatic condition of area.

Objective of the Study

Opencast mining method is adopting for exploration of Lignite, Clays, Gypsum, Fuller's earth, Limestone, Sandstone etc. in the district and by this solid waste generation and its disposal, trading and transport of mined out important mineral material are major activities in the district. Due to indiscriminate quarrying of minerals in the area, the mined out land getting undulating, barren, unfertile, dumped and spoils. Ditches and unorganized trenches are common. Dust generated by quarrying and transportation of minerals are responsible for several severe health problems. Large scale land transformations, unscientific mining, unsegregated waste dumps, incompatible land uses and improper waste disposal have caused land degradation, visual impact, loss of aesthetics, pollution of land, air and surface water bodies are getting degraded in its quality severely in the area.

Study Area

The study area is a part of Bikaner (Fig.1) district which is situated in the North-Western part of Rajasthan and central part of Great Indian Thar Desert. It is bounded by 27°11' to 29°3' North latitudes and 71°54' to 74°12' East longitudes. The district of Bikaner is part of Bikaner-Nagaur Basin and rock sequences exposed here are of Tertiary age. The subsurface data indicate extension of Tertiary sediments even up to Karanpur area in the Ganganagar District.

Regional Geology

On the basis of the surface and subsurface data, the tertiary sequences comprise three formations (from older to younger): Palana Formation, Marh Formation and Jogira Formation. Windblown sand, alluvial sand, ferricrits and gypsite beds overlie the sequence and form Kolayat formation recent deposits. The northern Rajasthan comprising the districts of Bikaner, Churu and Nagaur witnessed marine transgression during the Lower Tertiary. The encroachment of sea was through an embayment, which came into existence during the end of Mesozoic between the two fault-bounded ridges trending ESE-WNW.

In this region, sedimentation started with the deposition of the Palana Formation of Paleocene age. This is succeeded by the Marh Formation (Upper Paleocene to Lower Eocene) and the Jogira Formation (Middle Eocene). The terrain witnessed complete withdrawal of sea, thereafter establishing essentially continental condition. Fluvial and arid to Eolian Kolayat Formation (=Mar Formation) was deposited later during the Quaternary period.

Review of Literature

A number of workers including Ghosh (1983), Harsh and Sharma (1995), Khosla (1973), Pareek (1984) and Singh (1953, 1969) provided systematic account of the geology of the Lower Tertiary sediments of the Bikaner region. Most of the areas of the Bikaner District are covered with desert sands and sandy alluvium of Quaternary period. The Tertiary rock-exposures are found only in certain places as detached outcrops. The rock-exposures are best developed around Kolayat, about 54 km WSW of Bikaner.Rajasthan produces 99% of the total mineral Gypsum production in India in which in Bikaner District most promising producer (Bhardwaj Rajat, 2016). The sediments in the Bikaner basin in Barsinghsar are tertiary coarse sands and gritty sandstone intercalated with clays and gravel having thickness of 60-80m (Manjhu and Rawal, 2015). Water is the most abundant physical substance and transparent liquid on the earth (Yadav, 2016). Assessment of Chemical characteristics of ground water is necessary because the physical and chemical parameters of ground water determine its suitability for drinking, agricultural, industrial and domestic purposes(Gupta and Maheshwari, 2018).

Material and Methodology

Sample Collection- 16 surface water samples were collected from mining affected areas and Non mining affected areas around Kolayat area during monsoon season in one litre clean plastic container according to the water quality standard guideline(WHO, 1993) presented in Table-1. Rain water collected in the mining pits, ditches, trenches and then it percolate in to underground with contaminations and surface water bodies like pond, Johad and nallah also get filled with water from their catchment during monsoon season.

Methodology

The sampling, preservation, digestion and preparations and the analysis of water samples are made as prescribed by standard methods of APHA 1998. Water quality parameter like TDS, pH and EC was determined on the spot using HI9813-6 meter. Analytical parameters like calcium, magnesium were analysed by EDTA titration method. F and NO_3 by UV-visible spectrophotometer,SO_4 by gravimetric method. sulphate and chloride were analyzed in the laboratory following the standard methods7-9. Sodium and Potassium were estimated using Microprocessor Flame Photometer (ESICO) Model 1381. TSS by Filtration (No.42) method. Analyzed results are given in Table-2.

Result and Discussion

Mining implication in Area

The mining operations in the area have definitely provides employments for local people and generates revenues for the government**.** Opencast mining method is adopting for exploration of Lignite, Clays, Gypsum, Fuller's earth, Limestone, Sandstone etc. in the district. The fertile top soil has been removed during excavation for minerals. Generation of solid waste and its disposal, trading and transport of mined out important mineral material are major activities in the district. The quality of ground water resources vary naturally and widely depending on climate, seasons, geology of bedrock as well as anthropogenic activities (Shandilya and Sharma, 2004).Due to indiscriminate quarrying of minerals in the area, the mined out land getting undulating, barren, unfertile, dumped and spoils. Ditches and unorganized trenches are common. Dust generated by quarrying and transportation of minerals are responsible for several severe health problems. Large scale land transformations, unscientific mining, unsegregated waste dumps, incompatible land uses and improper waste disposal have caused land degradation, visual impact, loss of aesthetics, pollution of land, water and air in the area. The surface water bodies are getting polluted and quality of water is also deteriorated.

Surface Water Quality Degradation

Surface water bodies are main source of drinking water in western Rajasthan. There is need to analyze the quality of water before its use foe different purposes. To know the idea about the health of water bodied water quality analyses is required. So water samples of surface water bodies of mining areas and non-mining areas during monsoon season were analyzed to see the changes and compare in quality. The monsoon water quality data are presented in Table- 2. The impact of limestone mining on water quality based on analyses of various physico-chemical parameters of water samples and its comparison with the results of unaffected water body at East JaintiaHills, Meghalaya shown degradation in water quality (Lamare and Singh, 2014).The graphical representations of different physico-chemical water parameters are also presented in figure-2 which clearly shows elevation in values of mining area samples and non-mining area sample analysis. The details various parameters are discussed as follows-

Electrical Conductivity (EC)

The values of EC were ranges from 160-180 µ S/cm for samples of nonmining area whereas for mining area it ranges from 265-1090 µ S/cm. The high EC value in mining area sample may be due to enormous quantity of dissolved ions in water bodies from mines.

Total Dissolved Solids (TDS)

The concentration of total dissolved solids ranges from 102-120 ppm for nonmining area whereas for mining area it ranges from 162 to 660ppm. The TDS increases in mining area samples.

Calcium (Ca)

The calcium are ranges from 11-16 ppm in nonmining area sample whereas in mining areas it ranges from 20 to 81. Sample no. S-5 (kolayat) area has cross the standard limit of (BIS: 75 mg/L).

Magnesium (Mg)

The concentration of Mg was reported to be lesser than the Ca concentration in both the cases. Magnesium content was found in all samples within the permissible limit of 30 mg/L in non-mining area with maximum magnesium concentration 9 mg/L and 46 mg/L for mining areas was cross the limit.

Total Hardness

As per water hardness classification; water samples having hardness (as $CaCO_3$) value ranged from 0-75, 75-150,150-300 and above 300 are classified as soft water, moderately hard, hard and very hard water. Among the analysed water samples, the non-mining area samples possess soft characteristic but athe samples of mining areas are showing value of moderately hard and very hard of Kolayat. Their hardness value for non-mining areas has exceeded the prescribed limits of BIS,1998 (300mg/L).

Sodium

Sodium concentration in water is generally found to be lower than that of calcium and magnesium concentration. Sodium concentration value found in 9-13 ppm for non-mining area samples. The maximum value for sodium concentration for mining samples was found to be 53 ppm.

The higher values of sodium of sample S-5 Kolayat may be due to addition of rocks mineral caused by fast flowing water in the mining areas and this water goes to pond and quarries.

Potassium

In the present investigation, potassium concentration of all the sampling sites of non-mining area ranged from 4 ppm to 7 ppm and the K concentration ranges from 3 ppm to 16 ppm for mining area samples.

Sulphate

The sulphate concentration was found 4-8 ppm in non-mining areas whereas in mining areas it was found 6-32 ppm. Higher valus in mining area samples may be due to dissolution of minerals of mining areas.

Chloride

The average chloride concentration in water samples collected from non-mining area is 26 ppm whereas the water samples of mining area having values are ranges from 41 -165 ppm. The anthropogenic activities can also increase chloride concentration in water bodies. Increasing chloride concentration increases the electrical conductivity of the water *(Hussain et. al,* 2011).

Total Suspended Solids (TSS)

Total Solids includes both total suspended solids, the portion of total solids retained by a filter and total dissolved solids, the portion that passes through a filter (American Public Health Association, 1998). Total Suspended Solids (TSS) are solids in water that can be trapped by a filter. TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage. Here in study area the the non-mining area samples of water bodies are ranges 6-12 mg/l but in water samples of mining area the TSS value ranges 28-64 mg/l. It reveals that the mining area water bodies are more affected hence suspended solids are too high in concentration. High concentrations of suspended solids can cause many problems for stream health and aquatic life.

Conclusions

The present investigation reveals that the surface water quality in the water bodies around mining area is deteriorated. It is find out that the concentration of TDS, Ca, Mg, Total hardness as $CaCO_3$, HCO_3 and TSS has higher values in the samples analyzed for mining area than non-mining area in the monsoon season. This deterioration in surface water quality of water bodies around mining area are due to mixing and accumulation of additional salts of mine wastes and its dumps which flow through rain water to the water bodies. These water bodies are source of drinking water and domestic uses for the local people.

Besides this due to adoption of unplanned and traditional mining methods, surrounding is getting disturbed. The topographic features, drainage pattern, destruction of vegetation, degradation of agricultural lands, spreading of spoils creating wastelands, noise pollution are causing with adversely affecting the underground water quality also.

Suggetions

It is most urgent requirement to draw sincere attention towards proper management and conservation for water bodies and mineral resources by the all concerned govt. departments, mine owners and management authorities. In connection with this an effective plan for protection of water sources and water conservation strategy must be developed and implemented as soon as possible in the area to save further more deterioration.

Acknowledment

Authors are grateful to Dr. Shishir Sharma, Head, Department of Geology, Govt. Dungar College Bikaner for providing necessary laboratory facilities, support and encouragement.

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Fig. 1- Google Map of Study Area around Kolayat, District Bikaner Western Rajasthan

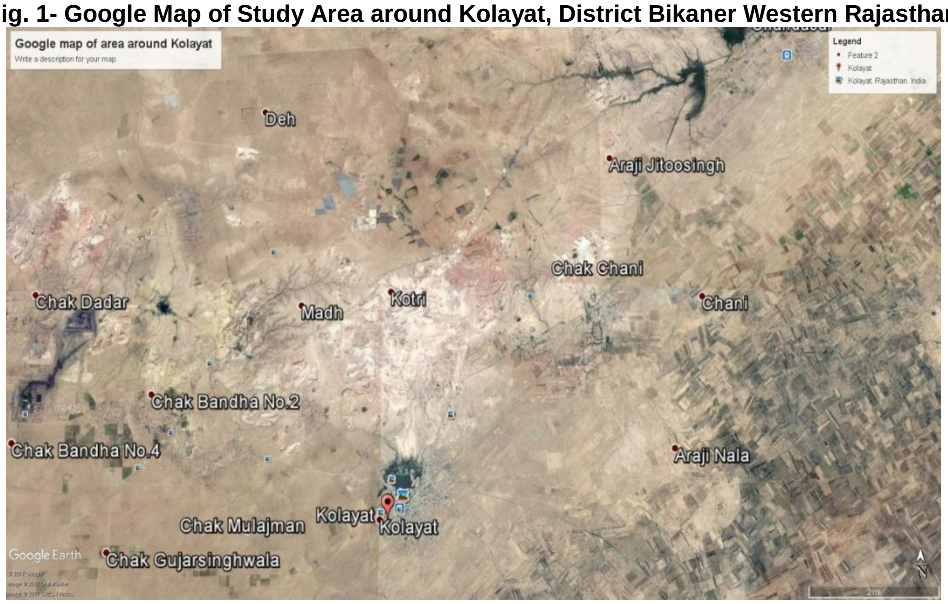


Table -1 Sample Locations of study area.

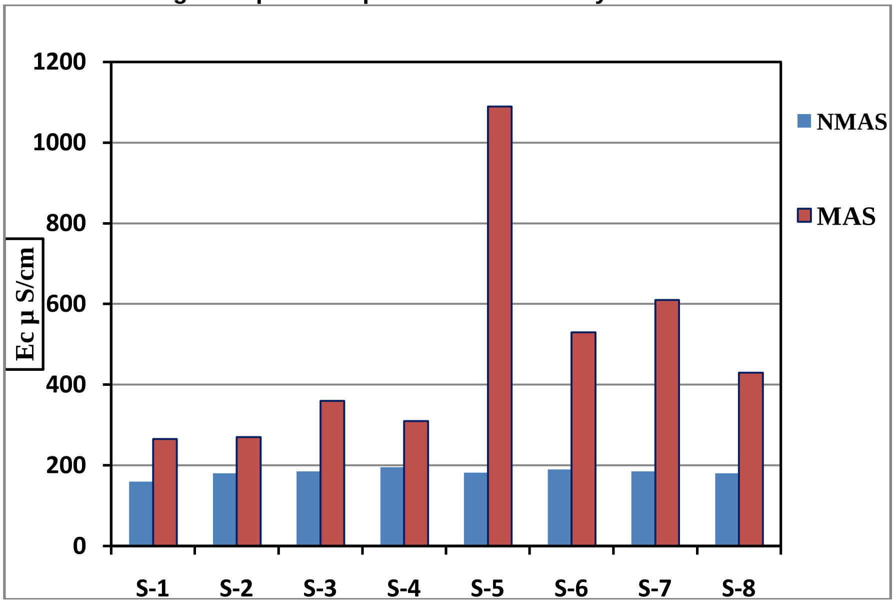
Sample.No.	Location	GPS Co-Ordinates	Area Type
S-1	Nal	N 28°02ʹ 55", E 73°11ʹ45"	Non-mining area samples
S-2	Darbari	N 27°58ʹ 56", E 73°06ʹ41"	
S-3	Golari	N 27°56ʹ 05", E 73°00ʹ15"	
S-4	Chandasar	N 27°55ʹ 50", E 73°02ʹ11"	
S-5	Kodamdesar	N 28°02ʹ 45", E 73°04ʹ43"	
S-6	Jaimalsar	N 28°03ʹ 43", E 72°59ʹ05"	
S-7	Khari	N 27°59ʹ 15", E 72°57ʹ25"	
S-8	Gajner	N 27°57ʹ 02", E 73°02ʹ44"	
S-1	Sankhala Fanta	N 27°53ʹ 29", E 72°57ʹ57"	Mining area samples
S-2	Kotri	N 27°52ʹ 56", E 72°56ʹ58"	
S-3	Jogira Fanta	N 27°52ʹ 02", E 73°54ʹ09"	
S-4	JogiraTalab	N 27°52ʹ 56", E 72°53ʹ51"	
S-5	Kolayat	N 27°53ʹ 58", E 72°58ʹ33"	
S-6	Madh	N 27°51ʹ 21", E 72°56ʹ10"	
S-7	Chani	N 27°53ʹ 19", E 73°00ʹ11"	
S-8	Indo kaBala	N 27°52ʹ 39", E 72°58ʹ52"	

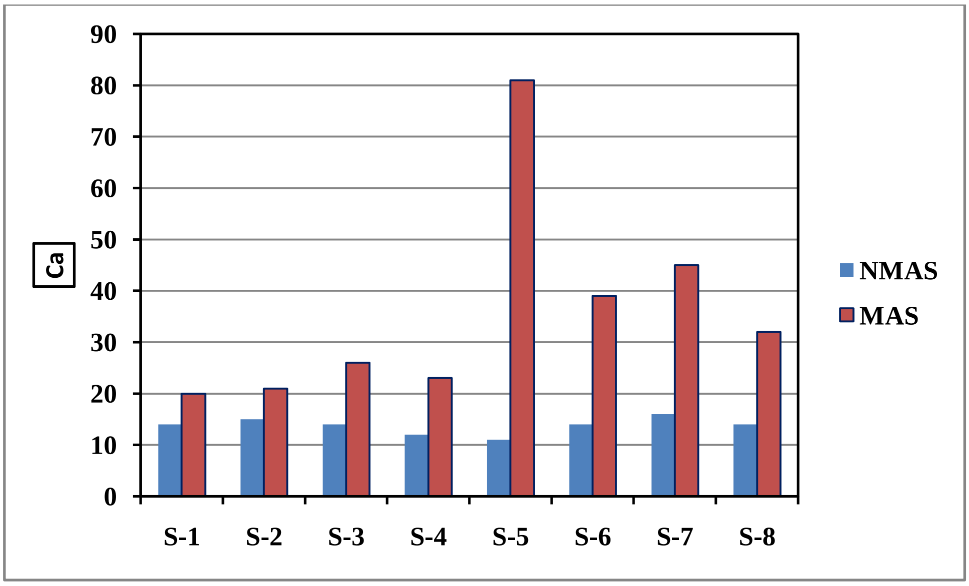
P: ISSN No. 2231-0045 RNI No. UPBIL/2012/55438 VOL.-7, ISSUE-1, August-2018
E: ISSN No. 2349-9435 Periodic Research

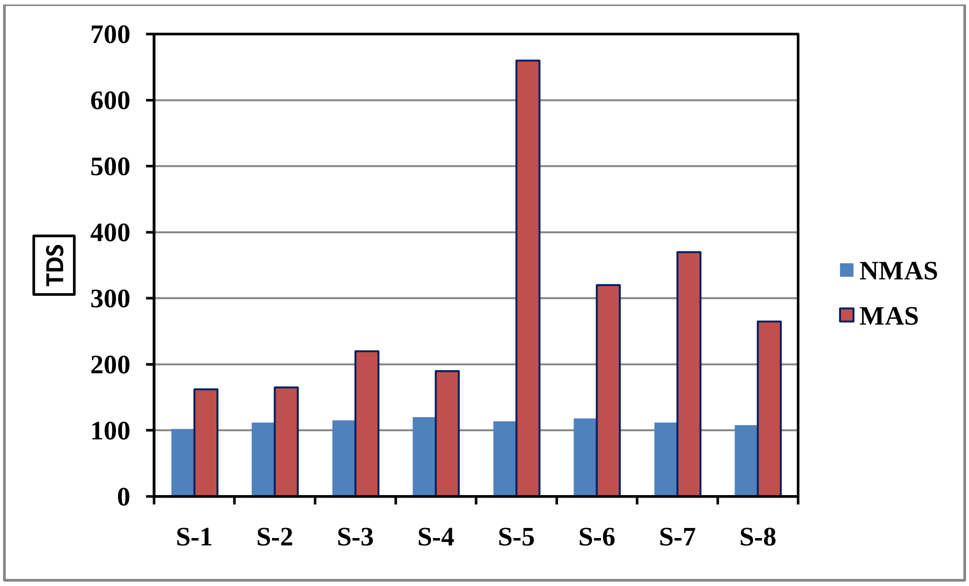
Table-2 Chemical Analysis of Water Samples of Study Area

	Non-mining area Samples							Mining area Samples									
Parameters tested/Location	Nal	Darbari	Golari	Chandasar	Kodam-desar	Jaimalsar	Khari	Gajner	Sankhala Fanta	Kotri	Jogira Fanta	Jogira Talab	Kolayat	Madh	Chani	Indo kaBala
Ec µ S/cm	160	180	185	195	182	190	185	180	265	270	360	310	1090	530	610	430
TDS	102	112	115	120	114	118	112	108	162	165	220	190	660	320	370	265
pH	7.21	7.19	7.24	7.12	7.13	7.16	7.12	7.11	7.24	7.8	7.34	7.56	7.82	7.34	7.26	7.42
Ca	14	15	14	12	11	14	16	14	20	21	26	23	81	39	45	32
Mg	8	9	8	6	5	6	5	5	12	13	16	14	46	22	26	19
Na	9	9	10	11	12	13	10	9	13	14	18	16	53	26	30	22
K	6	4	5	7	5	6	4	4	8	9	3	5	16	4	3	6
Cl	26	28	29	26	28	24	26	23	41	42	55	48	165	80	93	68
CO3	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
HCO3	42	45	46	42	38	42	38	34	65	66	88	76	264	128	148	106
SO4	4	5	5	4	8	7	6	5	7	8	10	8	32	10	6	13
NO3	22	26	34	26	24	26	24	26	21	16	23	32	26	28	35	48
F	0.56	0.66	0.82	0.55	0.54	0.48	0.21	0.18	0.91	1.04	1.32	1.28	1.41	1.08	0.94	1.14
TH as CaCO3	74	80	75	52	58	54	53	52	108	114	140	124	428	206	239	172
TSS	6	9	12	6	8	6	8	6	28	42	64	36	54	44	37	42

Fig.2 Graphical Representation of Analyzed Results






TDS
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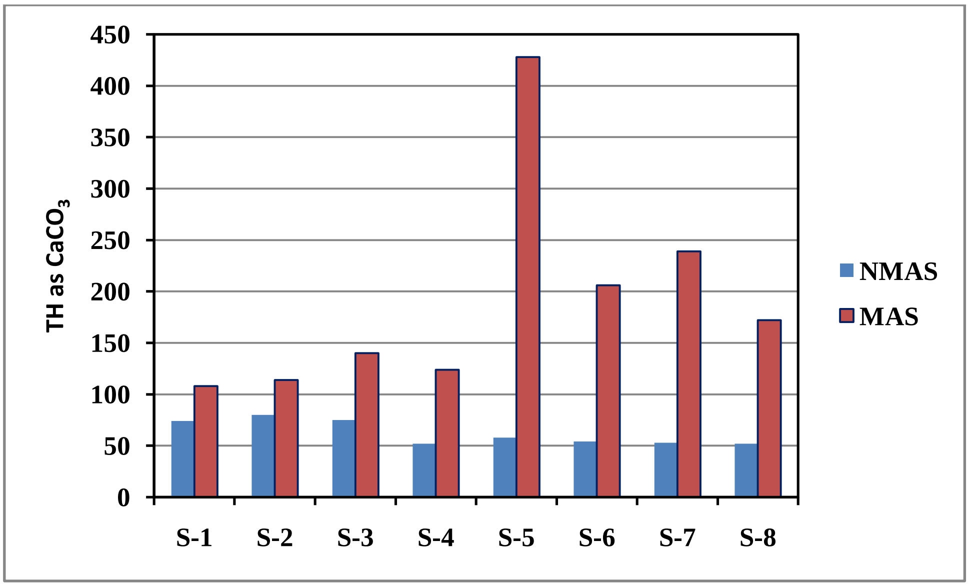
NMAS
MAS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S-1
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S-3
S-4
S-5
S-6
S-7
S-8
NMAS
MAS