SHORT COMMUNICATION

ENVIRONMENTAL IMPACT OF MARBLE MINING AROUND MAKRANA, NAGAUR DISTRICT, RAJASTHAN

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Conventional and unscientific mining poses severe threat to life, public property and continuation of mining in the area. Incompatible land uses, huge waste dumps and large scale land transformation have resulted in land degradation, ponding, flooding, water contamination and health hazards in Makrana mining area. Segregation of dumps, compatible land use and research and development activity for use of marble slurry are suggested measures for reclamation and restoration of the degraded land.

INTRODUCTION

Makrana (Lat. 27°02'25" N; Long. 74°43'44" E) is situated at eastern margin of the Thar desert and has an ancient marble mining history. The Makrana marble has made a perceptible dent in marble industry because of its blockability, whiteness, (high CaO 50-56 %, low MgO 0.90-1.77 %), good polishing character and lustre. It is fine grained and exhibits stable, well distributed colours, pleasing and attractive designs and patterns. The transluscent varieties of Makrana marble are preferred over other marbles for monumental and sculptural work (IBM, 1993).

GEOMORPHOLOGICAL AND GEOLOGICAL SET-UP

Geomorphologically, the area is represented by strike ridges, sand sheets, anthropogenic overburden mounds, slurry dumps and deep pits. Drainage in the mining area is mostly internal. Major part of the area is covered by mobile to semi stable, NNW-SSE to NE-SW trending sand dunes which overlie calcareous sand, pseudo-conglomerate, kankar or gypsite beds of Quaternary period. Marble is exposed on surface in the central part, whereas overburden varies upto 15 m in the northern and the southern part of the area.

General slope in the mining area is towards west and northwest. Mining at present is below the water table in old mines. Water table in the area is 30-40 m below ground level. Groundwater from the mines is released into open lands and agricultural fields.

Makrana marble deposits belongs to the Ajmer Formation of Kumbhalgarh Group of the Delhi Supergroup (Pareek, 1984; GSI, 1997). According to Sinha Roy et al. (1998) Makrana marble is northeastern extension of the Ras marble and its stratigraphic position is debatable. The Alwar Group of rocks towards east are overlain by the Ajmer Formation (Ajabgarh Group) comprising of medium to coarse grained, cherty, ferruginous and/or micaceous quartzite (Fig.l). The Ras Formation of the Kumbhalgarh Group, considered coeval with the Ajmer Formation, comprises greyish white to pink marble and dolomitic marble and is exposed west of Makrana. Marble occurs as thin parallel bands associated with calc-silicate rocks and calcareous quartzite having NNE-SSW strike and steep easterly dips. The rocks of Bombolai Formation of Punagarh Group are the youngest rocks of the Dellii Supergroup in the area. These consist of biotite gneiss, quartz mica schist, actionolite-tremolite schist, phyllite, ferruginous quartzite, grey impure marble and calc silicate rock. The exact interrelationship of these rocks is not known due to paucity of outcrops. Rocks of the Delhi Supergroup have been intruded by the Erinpura Igneous suite comprising porphyritic granite, biotite granite, pink granite, leucogranite and pegmatite.

Five prominent marble bands occur in the area west of Makrana. From east to west these are known as: (1) Devi-Gunawati range, (2) Dungri range, (3) Pink range, (4) Makrana Kumhari range, and (5) Borawar Kumhari range with band I and U (Natani, 2001). The different marble bands have formed due to tight isoclinal folding. The mining ranges are known by different names in different blocks (Fig. 2). At present mines extend from Matabhar in the north to Bilu-Mored in the south (approximately 13 km) along the strike and from Gunawati in the east to Borawar in the west (about 1.6 km) across the strike. Matabhar, Kalanada, Kolhadungri and Bilu-Mored are new mining areas.

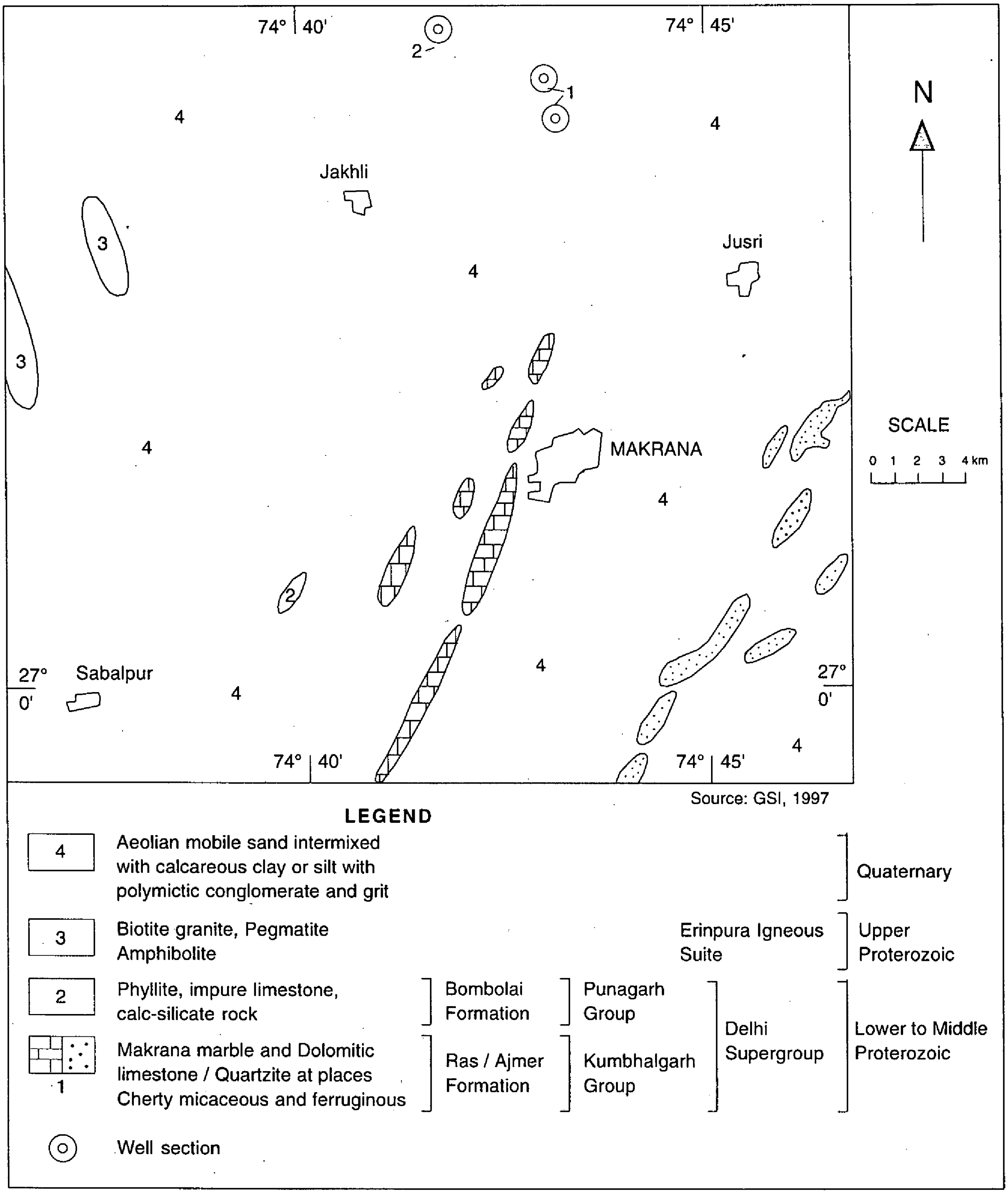

Fig.1. Geological map of area around Makrana, Nagaur District, Rajasthan.

MINING RELATED ACTIVITIES AND THEIR IMPACT ON ENVIRONMENT

Open cast mining, marble processing, solid waste generation and its disposal, trading and transport of marble blocks, slabs and irregular marble pieces (khandas), and art and craft work are important activities in Makrana mining area. Quarrying is by conventional rope and bucket method and the quarries run along the strike and dip of marble bands. Large scale land transformation, unscientific mining, unsegregated waste dumps, incompatible land uses and improper waste disposal have caused land degradation, ponding and flooding of water, visual impact, loss of aesthetics, pollution, health and safety hazards.

Safety Hazards and Loss of Public Property

Blasting of rocks mass is done to detach blocks of marble and remove hanging wall strata. Undercutting, side cutting and removal of safety pillars thus make the hanging wall strata unstable. Dewatering of mine pits and under cutting of loose aeolian sand by water released from processing plants results in failure of hanging wall strata and consequent mine collapse and loss of public property. Instances of unsystematic, unscientific and adhoc mining like rat hole mining, mining on small rent cum royalty lease holds of the size 3 m x 5 m (in Bapi mines) as against the norm of a minimum 2.25 ha laid down in the marble policy (Govt, of Rajasthan, 1994), undercuts and removal of safety pillars are quite common in the area.

Casualty figures provided by Makrana Police Station and Parbatsar Police station reveal 20 persons died of mine accidents during the period January 1999 to April, 2000. A major accident occurred in the area few years back in Chuck dungri range mines near Makrana railway station. Nearly 500 m of Makrana Parbatsar broad gauge line of Western Railway collapsed in the accident resulting in closure of 54 Chuck dungri mines for more than 3 years. Thus looking at the size of operations, conventional open cast mining at 50 m to 100 m depth b.g.l., without any benches and complete ignorance of safety norms, recurrence of such accidents in future cannot be ruled out. Jodhpur-Makrana road, Borawar bye pass, Devi-Gunawati mines, Chousira mines, Rewat dungri mines and pink range mines are other spots vulnerable to such hazards in the area (Fig. 2).

Land Degradation and Loss of Aesthetics

Makrana mining area has witnessed large scale land transformations during last thirty years, leading to land degradation and loss of aesthetics. The quarry area increased from less than 100 ha in 1970 to more than 350 ha during the period 1970-1998. Marble production has also increased from 200 thousand tonnes in 1986 to 581 thousand tonnes in 1999-2000. Comparison of 1967 aerial photographs and IRS 1C Geo-coded data product of 20th February, 1998 for the area reveals large scale land transformation in the area. Quarries and associated dump area has increased from 1.875 km^2 in 1967 to 11.21 km^2 in 1998, whereas the built-up area around Makrana has increased from 1.10 km^2 to 5.00 km^2 during the same period. Built up area of Makrana Borawar, Gunawati and Bidiyad towns and surrounding villages and industrial land and waste dumps have increased manifold to accommodate increased mining and related activities in the area. Mine pits, waste dumps and abandoned pits dot the area throughout.

The huge excavation around Makrana has resulted in large anthropogenic mounds and deep trenches. The entire landscape has been degraded and turned into derelict land, as there is no planned reclamation and restoration of quarried landscape. Natural ground slope has been obliterated causing ponding and flooding of water. Unscientific mining, improper waste disposal, high waste generation, lack of vegetation, suspended particulate matter from blasting, dried marble slurry, overburden material and unsegregated waste dumps also cause aesthetic nuisance.

Air and Water Quality

Dried slurry from 317 marble cutting and polishing units, dust from over- burden dumps, blasting in mine pits and marble chip making plants contributes suspended particulate matter (SPM) in and around Makrana mining area. The size analysis indicates that sand size particles constitute about 90% (by weight) of the overburden dumps and about 60-70% of the slurry dumps. Silt and clay size particles are present in substantial amount in slurry dumps (about 30-40 %). Large number of trucks, jeeps, water tankers and mining machinery contribute to oxides of nitrogen (NOX), Carbondioxide ($C0_2$) and Sulphur dioxide ($S0_2$) emissions within the mining area. Other sources of air pollution in the area are lime-kilns and brick kilns. The oxides of nitrogen and sulphur (NOX and $S0_2$) are created by the burning of fossil fuels (mainly coal) being utilised in lime-kilns and brick kilns. Occurrence of these toxic gases and particulate matter together have adverse effects on human health in Makrana as revealed by verbal enquiries from Chief Medical and Health Officer, Makrana Government Hospital, mine labourers, traders and local population. Common complaints are of eye irritation and inflammation and lung infections. The presence of SPM can also be appreciated by seeing the white dust deposition on plant, stems, branches and leaves and on the face and hairs of persons moving in

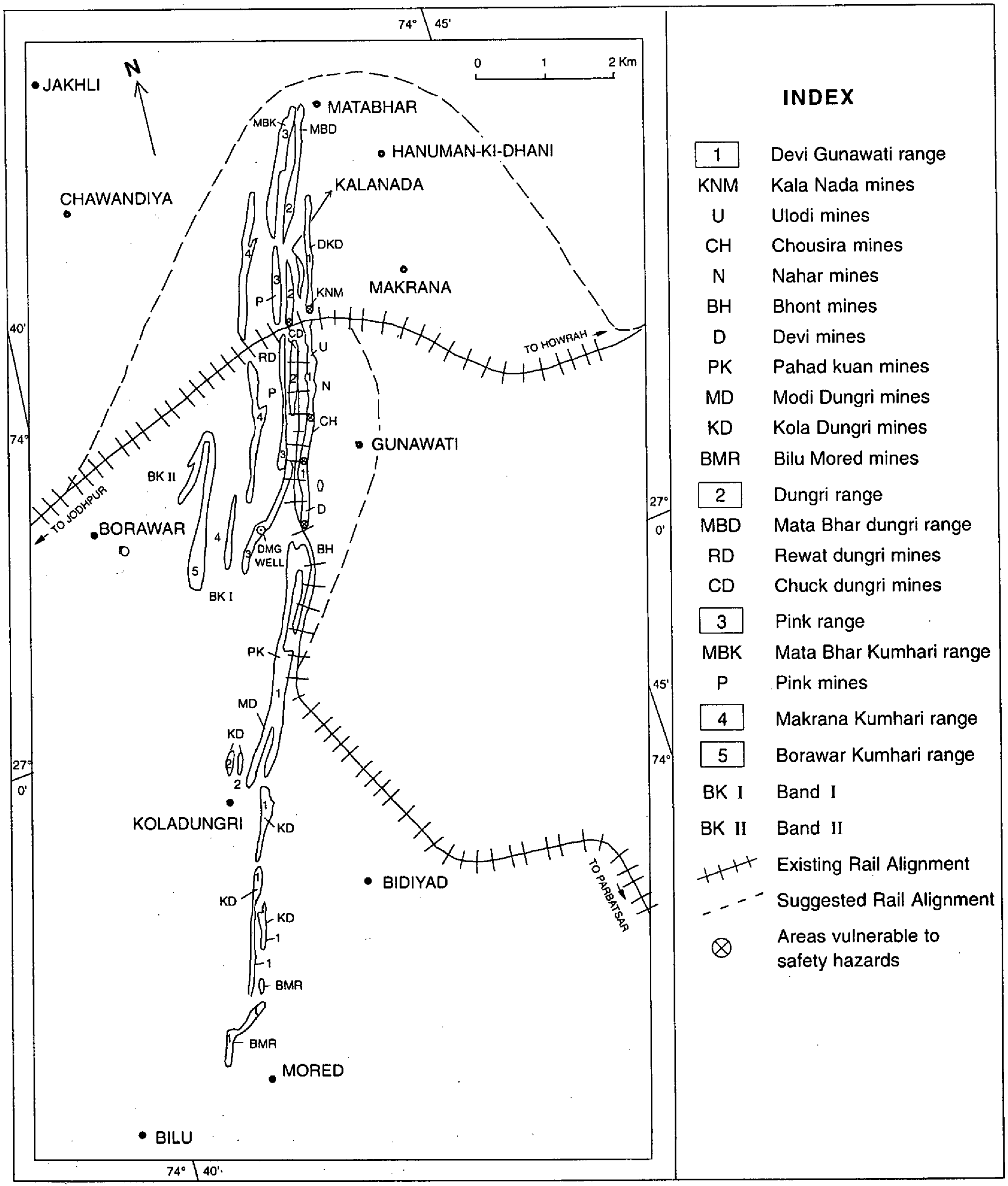

Fig.2. Marble quarries and suggested alignment of railway lines, Nagaur District, Rajasthan.

the area. Surface water bodies in the down wind direction of the mining area show high SiO_2 as compared to the silica content of natural water which is in the range of 1 to 30 ppm Table 1. High silica values in Gangwa Talao (140 ppm) and Manglana Talao (250 ppm), both in the predominant down wind direction (southwest to northeast) are due to contamination of these water bodies from suspended particulate matter. Parbatsar Talao which is 17 km SE of mining area does not fall in the wind direction, has analysed 40 ppm silica. Borawar Talao situated on the western periphery of mining area is in the upwind direction has analysed 5 ppm SiO_r Gunawati Talao situated in the down wind direction has analysed 5 ppm SiO, only as it falls in the shadow zone due to industrial units and buildings around it.

Extension of mining and related activities has resulted in encroachments and indiscriminate dumping of municipal and industrial waste around Kalanada in a small pond northwest of Makrana railway station. The water of Kalanada pond was used as drinking water source till 1967. Kalanada water has analysed, Biological Oxygen Demand (BOD) 70 mg/litre, Chemical Oxygen Demand (COD) 269.6 gm/ litre, Total Coliform organisms (TCO) 1100 Most Probable Number (MPN) per 100 ml of sample and E coli 23 MPN per 100 ml of sample, (Table 1). It is severely polluted as per drinking water norms (BIS, 1988, 1991). During rains, Kalanada water starts flooding the slums in the adjoining areas, burial ground east of Kalanada mine and Bhankron-ki-Dhani area. To prevent flooding of these areas excess Kalanada water is released into Kalanada mine through overflow drains. The polluted Kalanada water thus, gets filled up in Kalanada mines and the mines remain closed for 3-4 months. Thus, contamination of ground-water occurs in the area through subsurface flow of contaminated Kalanada water. Bhankron-ki-Dhani well about 400 m northeast of Kalanada mine has analysed BOD (12), COD (25.4) and TCO (23) indicating bacterial and industrial contamination of groundwater in the area due to mining in Kalanada range. Thus, diverting the polluted water of Kalanada into Kalanada mines solves although temporarily, the problem of flooding in the area, is likely to create a large problem of polluting groundwater aquifer in the long run "counterintuitive result".

Prime sources of water pollution in the afea are marble slurry and over burden dumps occupying large area in the core zone, water released from mine pits and unsegregated dumps of municipal waste, industrial waste and overburden. High values of one or more elements like Ca, Mg, SO_4, NO_3 and SiO_2 in Rewat dungri mine pit, Ulodi mine, Borawar tube well, Kolhadungri mine pit, Idgah well, Directorate of Geology and Mining Monitoring well in pink range, Kalanada pond, Gangwa Talao and Manglana Talao can be attributed to contamination of groundwater aquifer through occasional overflows from these waste dumps Table 1. It may be mentioned here that siliceous and dolomitic marble from other marble producing areas like Rajnagar, Udaipur, Andhi, Banswara and Ajmer area is also processed at Makrana in large quantities and this probably contributes silica and magnesium in water.

Beneficial Impact

The only beneficial impact of Makrana marble mining is on the socio-economics of the region. Makrana marble mines contributed Rs.9.64 crores to the state exchequer in the form of royalty, Rs. 15.27 crores in the form of sales tax and Rs. 4.60 crores as excise duty during the year (1997-98) DMG (2000). The mines provide job opportunities to more than 50,000 persons who are entrepreneurs engaged in the mining and related works or skilled, semi-skilled and un-skilled labourers or traders.

Suggested Remedial Measures

Use of natural resources and their transformation into economically valuable commodities has to be sustainable (WCED, 1987). Otherwise, the very base of development will be eroded. Marble mining at Makrana is a classic example of unscientific mining and improper waste disposal in total disregard to aesthetics, proper land use practices etc. Mining and waste disposal practices prevalent in the area need to be reviewed. Processing waste can be disposed of in abandoned pits and gully erosion areas northeast of Jusri and east of Bidiyad railway station. Segregation of overburden, mine muck, marble slurry and municipal waste dumps is suggested to prevent contamination of groundwater and land reclamation and restoration. Land reclamation is also easier and cheaper if mining waste is segregated. Value of marble depends on its size, whiteness, fine texture and absence or presence of cracks, fractures, etc. It is, therefore, suggested that as far as possible blasting should be avoided and deployment of wire saw machines be encouraged for mining. Amalgamation of small lease holds and mining on co-operative basis needs to be explored in consultation with mine owners, government representatives and environmentalists for sustainable development of the mining area. This will also help in simultaneous reclamation and restoration of mines. In addition to these remedial measures, vegetation screens all around mining belt, stabilisation of overburden dumps, realignment of Howrah-Jodhpur and Makrana-Parbatsar railway lines are suggested for the environmental management of the area (Fig.2).

Table 1. Water Quality Data – Makrana Marble Mining Area, Nagaur District, Rajasthan

Elements / Parameters				pH	TH	TDS	Cl	Ca	Mg*	Na	K	SO_4	NO_3	F	B	SiO_2	CO_3	HCO_3	BOD	COD	TCO	E coli
Desirable limits (BIS (1991)				6.5-8.5	300	500	250	75	30	Not defined	Not defined	200	45	1.00	1	30	Not defined	Not defined	Nil	Nil	Nil	Nil
Maximum permissible limits in absence of alternative source (BIS, 1991)				#	600	2000	1000	200	100			40	100	1.50	<5	50	Not defined	Not defined	30	250	<10	Nil
S.No	**Location**	**Type of Sample**	**Remarks**	**pH**	**TH**	**TDS**	**Cl**	**Ca**	**Mg***	**Na**	**K**	**SO_4**	**NO_3**	**F**	**B**	**SiO_2**	**CO_3**	**HCO_3**	**BOD**	**COD**	**TCO**	**E coli**
1.	Kala Nada	Surface water	Sewage and industrial contamination	8.15	584	2020	505	145	51	500	80.00	ND	50	<1	1	75	ND	1250	70	269.6	1100	23
2.	Borawar	Treated slurry	Industrial contamination	7.90	2840	3300	42	336	480	185	32.36	2673	60	0.25	ND	5	ND	273	ND	ND	ND	ND
3.	Ulodi	Slurry water from processing plant	Industrial contamination	8.25	2500	3985	619	588	219	300	34.00	1850	106	1.50	20	75	4.3	132	ND	17.6	ND	ND
4.	Borawar Talao	Surface water	Permissible	8.60	180	450	100	48	14	50	20.00	ND	70	1.00	<1	<5	26	71	ND	ND	ND	ND
5.	Gangwa Talao (1)	Surface water	Permissible	8.20	216	838	66	38	29	171	2.57	62	20	0.50	ND	140	ND	353	ND	ND	ND	ND
6.	Gangwa Talao (2)	Surface water	Permissible	8.20	215	1020	360	20	40	250	17.00	ND	50	<1	<1	5	13	195	ND	ND	ND	ND
7.	Manglana Talao	Surface water	Contaminated (High F, SiO_2 low TDS)	7.99	88	215	10	49	4	50	7.30	22	<10	7.50	ND	250	ND	233	Nil	17.6	Nil	Nil
8.	Parbatsar	Surface water	High F, Low TDS	7.87	88	170	7	35	Nil	25	6.72	33	<10	2.25	ND	40	ND	92	ND	ND	ND	ND
9.	Talao Borawar	Composite water of municipal supply tube well No. 1, 3, 5 & 6	Not fit for drinking due to excessive pH	9.10	180	1280	440	16	34	370	5.00	85	50	1.00	2	48	35	371	ND	ND	ND	ND
10.	Kuchaman	Chlorinated composite water of municipal supply tube wells	High SiO_2; Low TDS	7.94	104	280	20	67	10	28	82.97	526	15	0.75	ND	200	Nil	75	ND	ND	ND	ND
11.	Bilu	Groundwater	Alkaline water with low TDS	8.90	170	455	75	28	24	86	1.70	55	42	<1	2	20	14	212	ND	ND	ND	ND
12.	Bhankron ki Dhani	Dug well water	Alkaline water; high SiO_2, B & NO_3	9.00	395	1020	370	48	67	264	7.00	225	105	<1	2	60	5	133	12	25.4	23	ND

Table 1 Contd....

S.No	Location	Type of Sample	Remarks	pH	TH	TDS	Cl	Ca	Mg*	Na	K	SO_4	NO_3	F	B	SiO_2	CO_3	HCO_3	BOD	COD	TCO	E coli
13.	Borawar	Tube well water	Contaminated high Ca, Mg, SO_4, F, NO_3	7.96	856	1350	50	195	88	119	2.24	632	75	2.50	ND	7	ND	420	ND	ND	ND	ND
14.	Chawandia	Dug well water	Excessive pH	9.10	90	1520	330	20	10	525	2.00	95	92	2.00	2.5	38	40	708	ND	ND	ND	ND
15.	Idgah Well	Dug cum bore well	Contaminated water	9.72	1033	3000	341	207	170	185	8.04	349	225	1.50	ND	40	ND	735	ND	ND	ND	ND
16.	Jhato	Dug well	High TDS, Na, NO_3 and Silica	8.65	510	2400	510	64	89	650	5.00	ND	750	<1	<1	60	26	641	ND	ND	ND	ND
17.	Kalwa	Dug well	Unfit for drinking excessive TDS, Cl, Na, K, NO_3 and F	8.55	720	7000	1534	82	154	3700	40.00	ND	1150	3.00	1	20	52	619	ND	ND	ND	ND
18.	Khokhar	Dug well	Unfit for drinking	8.40	1500	5960	2690	156	278	1500	100	1050	14	<1	1.8	68	5	97	ND	ND	ND	ND
19.	Laroli	Dug well	Permissible	8.70	80	1085	234	16	10	395	1.00	75	16	<1	<1	10	26	590	ND	ND	ND	ND
20.	Manglana	Dug well	Unfit for drinking	9.13	160	1585	370	20	26	480	133	ND	200	<1	1	30	33	708	ND	ND	ND	ND
21.	Pink range Gunawati	Dug well (DMG)	High B, COD	8.45	250	1370	310	32	41	425	3.00	127	38	1.00	2	40	13	646	ND	17.6	ND	ND
22.	Sabalpur	Dug well	Low TDS, High NO_3	8.95	140	480	90	12	26	120	1.30	ND	80	<1	<1	30	30	186	ND	ND	ND	ND
23.	Chuck Doongri	Mine pit water	Permissible except fluoride	8.16	320	1400	105	64	38	200	4.39	105	60	2.25	ND	5	ND	500	ND	ND	ND	ND
24	Kolha Doongri	Mine pit	Excessive pH and NO_3	9.18	160	920	268	16	29	390	2.00	ND	250	<1	<1	40	39	487	ND	ND	ND	ND
25.	Gunawati	Pink range mine pit	Contaminated high SiO_2	8.14	256	740	119	20	36	111	4.30	60	15	0.75	ND	300	ND	367	ND	ND	ND	ND
26.	Rewat Doongri	Mine pit	Permissible	7.43	846	1876	172	182	94	193	8.21	47	20	0.50	ND	40	ND	644	ND	ND	ND	ND
27.	Ulodi	Mine pit	Contaminated High SO4, Na, SiO_2 and COD	8.80	430	1380	430	56	70	285	10.00	300	30	<1	1.5	77	13	177	ND	17.6	ND	ND

Note: All values are in ppm except pH. Total Coliform Organisms (TCO) and E Coli are in terms of most probable number MPN/100 ml of sample. ND - Analysis not done. *As per BIS 1993; ! As per BIS 1988; # No relaxation below 6.5 and above 8.5

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