Disposal Options of Marble Slurry
In
Rajasthan

2011-12

Central Pollution Control Board
Zonal Office (Central)
Bhopal

Central Pollution Control Board

Zonal Office (Central)

Bhopal

REPORT

ON

DISPOSAL OPTIONS OF MARBLE SLURRY IN RAJASTHAN

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Content

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चमकीले पत्थर 'मार्बल' निर्मित विश्वप्रसिद्ध ताजमहल, विक्टोरिया मेमोरियल महल, दिलवाड़ा मंदिर व बिरला मंदिर जैसी अनेकों इमारतों, मक़बरो एवं मंदिरो ने सब का मन मोहा है। भू-गर्भ के अत्यधिक ताप व दाब उपरांत कायांतरित चट्टानों में रूपांतरित अवसादी व आग्नेय चट्टान का ही एक नाम मार्बल है जिसका की राजस्थान के कुल 33 जिलो में से 16 जिलो में खुदाई व प्रसंस्करण किया जा रहा है। कुल 1100 मिलियन टन मार्बल की खुदाई व प्रसंस्करण हेतु 4000 खदानें तथा 1100 प्रसंस्करण इकाइयाँ राजस्थान के मुख्यतः पाँच क्षेत्रो (उदयपुर-राजसमन्द-चित्तोडगढ़, मकराना-किशनगढ़, बाँसवाडा-डूंगरपुर, जयपुर-अलवर तथा जैसलमेर) में कार्यरत है।

मार्बल खुदाई क्षेत्रो के आधार पर प्रचलित भैसलाना ब्लैक, मकराना अलबेटा, मकराना कुमारी, मकराना डूंगरी, आँधी इंडो, ग्रीन बिदासर, केसरियाजी ग्रीन, जैसलमेर यलो व अन्य अपने रासायनिक संरचना के कारण अलग-अलग बनावटों में पाये जाते है। मार्बल का सफ़ेद , लाल, पीला व हरा रंग क्रमशः केल्साइट, हेमाटाइट, लिमोनाइट तथा सरपेंटाइन स्वरूप के कारण होता है।

मार्बल खुदाई उपरांत प्रसंस्करण हेतु गेंगसा इकाइयो पर आवश्यक मोटाई में काटा जाता है। इस प्रक्रिया में 30-35% मार्बल अपशिष्ठ निकलता है जिसमें 70-75% पानी होता है। इस प्रकार कुल 1100 प्रसंस्करण इकाइयों से 5-6 मिलियन टन मार्बल अपशिष्ठ प्रति वर्ष उत्पादित हो रहा है। जिसको संबंधित मार्बल असोशिएशन द्वारा टेंकरो कि मदद से उपर्युक्त स्थान पर निस्तारण किया जा रहा है। मार्बल पाउडर के <75 माइक्रोमीटर से भी बारीक कण पर्यावरणीय जल, वायु प्रदूषण को बढ़ा रहे है। ये बारीक कण हवा में फैल कर स्वास्थ्य संबंधी बीमारियाँ अस्थमा, आंखो में जलन व त्वचा जैसे रोगों को भविष्य में बढ़ा सकते है। पौधों के श्वास छिद्रो के बंद होने से इनमे बढ़ने कि क्षमता कम हुई है एवं जमीन पर इन बारीक कणों के जमने से मिट्टी कि उर्वरक क्षमता में बहुत गिरावट आई है।

केंद्रीय प्रदूषण नियंत्रण बोर्ड, आंचलिक कार्यालय भोपाल ने विषय कि गंभीरता को समझते हुए मार्बल अपशिष्ठ के निस्तारण हेतु किशनगढ़, मकराना, राजसमन्द तथा उदयपुर के मार्बल प्रसंस्करणों का सर्वे किया व अपशिष्ठ के उपयुक्त निस्तारणों के विकल्पों पर सीमेंट उद्योगों, मिनरल ग्राइंडरों, मार्बल संघों के प्रतिनिधियों के साथ चर्चा आयोजित की।

मार्बल में पायी जाने वाले मैग्नीशियम ऑक्साइड (MgO) की प्रतिशतता (4-22%) के चलते ही इसे सीमेंट उधोग उपयोग में नहीं ला पा रहे है। केल्साइट मार्बल में पाई जाने वाली इसकी कम मात्रा को जे के सीमेंट, बिरला सीमेंट उधोग व्हाइट सीमेंट बनाने में काम ले रहे है।

मार्बल अपशिष्ठ में 26-47% में पाये जाने वाले केल्सियम ऑक्साइड को रासायनिक प्रक्रिया द्वारा जिप्सम में रूपांतरित कर इसे सीमेंट उधोगों में प्रयोग में लाया जा सकता है।

केंद्रीय सड़क अनुसंधान संस्थान, नई दिल्ली के अनुसार 20-25% मार्बल पाउडर को सड़क निर्माण में फिल्लर के रूप में काम में लाया जा सकता है। जोकि एक किलोमीटर सड़क निर्माण में रुपये 75,000/- व 1000 टन मिट्टी की बचत के रूप में फलीभूत हो सकता है।

मिनरल (क्वार्ट्ज़, फेल्सफार व सोडा) ग्राइंडिंग इकाइयों में कच्चे माल के रूप में 15-20% मार्बल पाउडर का उपयोग किया जा सकता है।

श्री सम्पत लाल सुराणा, आविष्कारक द्वारा 'लो कोस्ट बाइंडर' की पेटेंटेड तकनीक का उपयोग कम भार सहन करने वाली दीवारों के निर्माण में किया जा सकता है।

राजस्थान प्रदूषण नियंत्रण मंडल द्वारा ऑरेंज श्रेणी में आने वाली मार्बल प्रसंस्करण इकाइयों को रेड श्रेणी में शामिल कर देने उपरांत मार्बल अपशिष्ठ निस्तारण हेतु इन विकल्पों को मार्बल उधोग में समायोजित करना अनिवार्य रहेगा।

Executive Summary

Rajasthan is the richest state in the country with regards to marble deposits (1100 Million Tons) both in quality & quantity. Around 4000 marble mines and 1100 marble processing units, spread over 16 Districts out of 33 Districts of Rajasthan. The important regions of marble deposits are Udaipur - Rajsamand - Chittorgarh region, Makrana - Kishangarh region, Banswara - Dungarpur region, Andhi (Jaipur) - Jhiri (Alwar) region and Jaisalmer region.

In the country, Rajasthan state has more than 95% of marble processors. Important processing centers in the state are Makrana, Kishangarh, Rajsamand, Alwar, Udaipur, Nathdwara and Abu Road. Earlier, the marble slurry generated through processing units was collected improperly & dumped at any abandoned land and near the roadsides. This kind of practice is still going on near to Chittorgarh, Nimbahera, Neemuch & Shahpura (Alwar) areas. However, due to Government orders on control of environmental pollution & public awareness, these kinds of activities have reduced & now the local Marble Associations have identified the disposal sites and the generated slurry is being disposed through tankers at identified sites without spilling out on roads.

To access the slurry management options, a preliminary survey was conducted during 13th January to 23rd January, 2012 at Kishangarh, Rajsamand, Makrana, Udaipur and Chittorgarh regions of Rajasthan. The survey followed by an interaction meet on 'Marble & Marble Slurry Disposal: Problem, Issues & Probable Solutions' at Kishangarh (Rajasthan) organized on 28th February, 2012 along with the representatives of Marble Associations, Cement industries & marble processing units.

About 1100 marble processing units all over the Rajasthan are generating around 5-6 Million Metric Tons of slurry every year. To manage this huge inorganic & non-hazardous waste in gainful/productive use, options were explored. Various stages/options of utilization of marble slurry are as below:

- Utilization of marble slurry in cement manufacturing
- Production of synthetic gypsum through chemical reaction with marble slurry
- Utilization of Marble slurry dust (MSD) in road construction
- Utilization of Marble slurry as a Low Cost Binder
- Utilization of marble slurry in brick manufacturing
- Utilization of marble slurry powder in mineral grinding plants

The feasibility of above options needs to be examined in detail in consultation with the various organization/institutes/industries like Cement manufacturer, NCBM, CRRI, CDOS etc to evaluate most techno-economical & viable solution/option of slurry disposal.

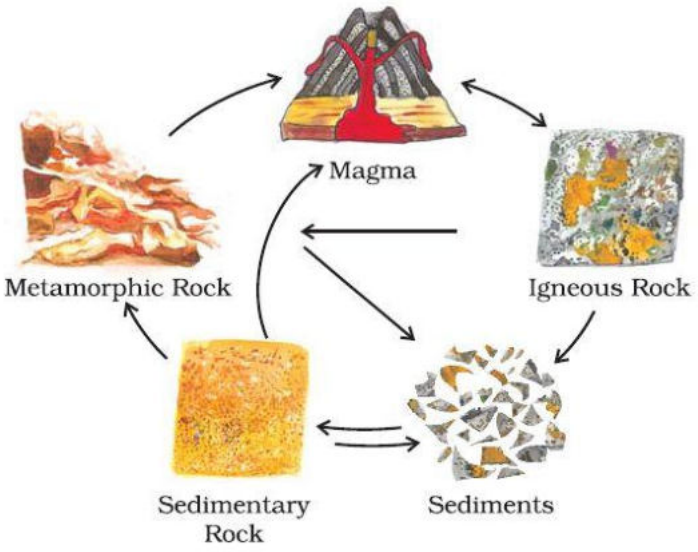
1. Marble

The word ‘marble’ is derived from Greek word *mármaron e.g.* "Crystalline rock" or ‘*Shining stone’*. Marble is the most preferred stone in India among all dimension stones because of its pleasant & transparent colors, uniform texture, smooth & shiny polished surface and silky feel.

The ‘Tajmahal’ at Agra & Victoria Memorial Palace, Kolkata are few of the remarkable monuments build of this shining stone ‘Marble’.

Marble is defined as a 'minor mineral' in Clause (e) of Section 3 of Mines and Minerals (Development & Regulation) Act, 1957.

In terms of geological definition ‘it is a metamorphosed limestone produced by re-crystallization under thermal condition and also regional metamorphism.’ Marble is a rock resulting from metamorphism of sedimentary carbonate rocks, most commonly limestone or dolomite rock. Metamorphism causes variable recrystallization of the original carbonate mineral grains. The purest calcite ($CaCO_3$) marble is white in color. Marble containing hematite (Fe_2O_3) is reddish in color where as limonite ($FeO(OH)\cdot nH_2O$) containing marble is yellow in color. The green color of marble is due to contains of serpentine $(Mg, Fe)_3 Si_2 O_5 (OH)_4$.



2. Deposits of Marble in Rajasthan

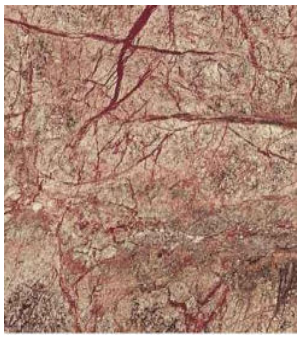
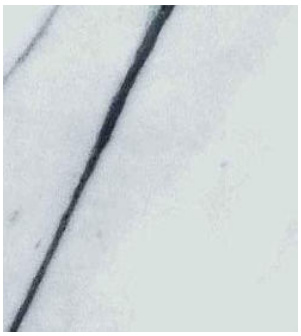
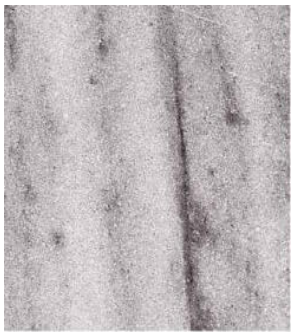
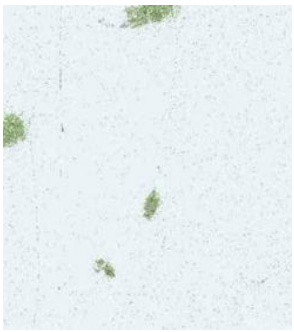
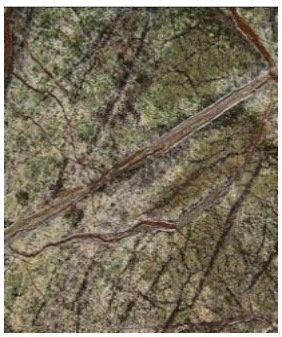
Rajasthan is the richest state in the country with regards to marble deposits (1100 Million Tons) both in quality & quantity. Around 4000 marble mines and 1100 marble processing units, spread over 16 Districts out of 33 Districts of Rajasthan. The state has 95% of the total marble processing units. The important regions of marble deposits are:

- Udaipur - Rajsamand - Chittorgarh region
- Makrana - Kishangarh region
- Banswara - Dungarpur region
- Andhi (Jaipur) - Jhiri (Alwar) region
- Jaisalmer region

District	Marble Deposits
Nagaur	Makrana, Borawad (white), Chausira, Dungri, Paharkuan (pink), Kumari, Ulodi, Pink Range, Kala Nada Talab
Jaipur	Bhainslana, Kotputli, Andhi, Raisala, Nimla, Todi Ka Bas
Alwar	Jhiri, Rajgarh, Dadhikar, Badampur, Kho, Baldegarh, Moti-Dungari, Malana, Goverdhanpura
Dausa	Dagota
Jaislamer	Moolsagar, Amarsagar, Badabag, Habur, Sipla, Jethwai, Narpia
Rajsamand	Kotri, Amet, Morwad, Agaria, Parvati, Morchana, Kelwa, Vani, Saprav Ka Guda, Thodi Nijharana, Talai, Umti, Jhanjer, Arna
Pali	Bar-Sendra, Diyana, Khiwandi, Sarangwa, Kantatiya, Sarangwa, Kundal, Dujara
Banswara	Vithaldev, Tripura Sundari, Kotharia, Khema-Talai, Bhanwaria-Talai, Oda-Bassi, Bhimkund, Prithvipura, Paloda
Udaipur	Babarmal, Devimata (Pink), Rikhabdev, Odwas, Masaron Ki Obri, (Green), Darauli, Tidi, Jaspura, Paduna, Manpur, Lohagarh, Sarvadi, Modi Chipala (White), Kela Kuan (Black)
Bundi	Umar, Pagara
Sirohi	Selwara, Iderla, Perwa-Serwa, Khandra, Deri, Morthala, Ajari
Dungarpur	Sabla, Nandili-Dad (calcitic), Peeth, Manpur, Dachki, Rohanwara, Mal-Surata (Green Serpentinitic)
Ajmer	Sursura, Narwar, Kali-Dungari, Torka, Ladpura, Roopnagar, Saradhana, Kekri, Umaria, Sawar, Ganeshnagar
Sikar	Kela-Dungari (Maonda), Patan
Jodhpur	Pachori, Chadi, Au, Moriya-Munjasar, Indolai Ki Dhani
Bhilwara	Jahajpur, Sarankhera, Kanti, Munjras, Panchanpura, Malola, Pansel, Manohargarh, Asind, Banera, Shahpura
Chittaurgarh	Mandal Deh
Churu	Dunkar, Charla, Bidasar

3. Varieties of Marbles

The nomenclature of marble is based on the mining range and color & texture of the marble. Makrana has various mining ranges, popularly known as Doongri, Devi, Ulodi, Saabwali, Gulabi, Kumari, Neharkhan, Matabhar, Matabhar kumari, Chuck doongri, Chosira etc. Doongri, Devi, Saabwali, Ulodi, Chosira and Neharkhan are famous for white marble, whereas Ulodi is famous for Albeto Marble. These mines produce white-brown marble. Gulabi stands for pink plain and pink Adanga marble whereas almost all mines produce Adanga marbles with brown and grey sheds. The marble used in 'Tajmahal' was mined at Makrana & was white in color so the marble variety was named 'Makrana White Marble'. Following are few varieties of marble:

Bhainslana Black	Fancy Brown Churu	Jaisalmer Yellow	Jhiri Onyx
			
Makrana Albeta	**Makrana Doongari**	**Makrana Kumari**	**Andhi Indo**
			
Keshariyaji Sea Green	**Rampura Black**	**Morwar**	**Fancy Green Bidasar**
			

4. Mine to Market

Queries of size (12'x40' to 325'x325' feets; 01 hectare or less) & large open-cast mines (maximum allowed area 50 hectares) are in operation at various regions of Makrana (Nagaur), Morwad area, Rajnagar (Rajsamand), Andhi (Jaipur), Salumber, Jaisalmer, Bidasar (Churu) etc. The world's largest marble miner *M/s R K Marbles Ltd,* has its processing unit at Kishangarh, Ajmer. Makrana has various mining ranges mainly Doongri, Devi, Ulodi, Saabwali, Gulabi, Kumari, Neharkhan, Matabhar, Matabhar kumari, Chuck doongri, Chosira and Pahar Kua amongst others. Rajnagar is the world's largest marble-producing area, with over 1100 gangsaws units located in the nearby town of Kishangarh to process the material produced. The mining at Andhi (Jaipur) is banned by the Supreme Court of India because of the vicinity of the area to the Sariska Tiger Reserve.

The site selection of marble mine is being done in consultation of Mining department. The removal of overburden is generally carried out with heavy earth-moving machinery. In some cases, the weathered zone is removed by drilling holes by jack-hammers and slim drill machines for the drilling purpose. These holes are charged with light explosives and under controlled blasting methods the over burden material is loosened out. After studying the topography, marble block is marked for removal from the query. By applying 'Continuous Manual Hammering' or 'Slim Drill Machines' to drill the holes through which diamond wire saw is passed and the block is cut by continuous motion of the diamond wire saw. The marble block freed from rock is toppled either pneumatically or by pulleys. The lifting and loading

of blocks are done by ‘Derrick cranes’ and using various types of loaders. The mined blocks transported to processing units through trucks.

Rajasthan state has more than 95% of marble processors. Important processing centers in the State are Makrana, Kishangarh, Rajsamand, Alwar, Udaipur, Nathdwara and Abu Road.

To cut the blocks in 2 to 3 mm thickness gang saw, wire saw and circular saw machines are used. In marble tile plant, the required thickness of tiles is 10 or 12 mm. For cutting circular saws are used. To polish the tiles polishers, trimmer machines are used. The rough and unpolished marble block, firstly received from mines ranges 15-20MT weight which is unloaded in the gantry yard with the help of Gantry Cranes. To remove the non-uniform surface of blocks, they are dressed on dressing machine before shifting to gangsaws.

After proper dressing, the block is shifted to gang saw having 75-125 saws in parallel. Each saw is brazed with number of segments called diamonds segments. These segments act as

teeth and cut block into required thickness. The normal thickness is 15-20 mm. This thickness of segment is approx. 5mm while saw thickness is 3 mm. On one gang saw on an average 20-40 Tons of marble is processed daily. During operation water is being continuously sprinkled on block to reduce the heat generation. The wet dust generated in cutting process is being stored in zigzag kind of water storage tanks. Due to sedimentation the dust (solid) settles down and the transparent supernatant water again reused for sprinkling over block. The water requirement is fulfilled by processer through water tankers. Average water loss per day is 1000Litres. The electricity requirement is done through Government Vidyut Vitaran Kendra's. Approx. 1000-1500 Kilowatt is required per day on each gang saw to process the block. The slurry (liquid marble dust) disposal is main cause of concern in current years. The processed marble in specific dimensions is being transported to 'Marble mandi' (Markets).

5. Water management

The water requirement of processor is fulfilled through water tankers & bore wells. The marble blocks processed on gang saw results in 30% waste generation. This contains 20-25% marble dust slurry and 5-10% of broken edges/slabs. The marble dust generated during process, make slurry along with the water, spread over the block. To recycle the water & to settle the marble dust, zigzag water-cum-dust storage tank are constructed. Through this zigzag movement & sedimentation process the dust settled at bottom. Alum as coagulator can enhance this sedimentation rate. The supernatant is again recycled to gang saw. In this settling process average water loss is upto 1000-1500 Ltrs per day. The semi-solid marble slurry is collected through pumps in tankers & transported for disposal at identified dumping site. However, earlier it was practiced to dump the slurry at any abandoned place. Decanter is provided at disposal site. The decanted water is also being used in marble processing. Other then the zigzag water treatment system, vertical settling tanks are also in use as shown in the photos.

To reduce the water consumption, filterpress has also been established by some of the units. Decanted water is recycled to gang saw units. The semi solid slurry collected in tractors and dumped in identified dumping sites. Due to less quantity of slurry generation from individual units, setting up a filter press at each unit is not economically viable. A group of nearby 10-20 units can setup a filter press among them.

Units requiring 10KL of water per day, needs to pay water cess. Whereas one gangsaw unit requires only 1KL water on an average. RSPCB has fixed Rs. 500/year payment from single gangsaw unit as a water cess.

6. Physical & Chemical Characteristics of Marble slurry

The quantity of slurry generation on marble processing is directly related to the thickness of gang saw blades e.g. to cut a 25mm block in 20mm block size with the 5mm thick blade will generate 20% of the marble waste. This slurry waste has 70% of water content and rest is marble dust. The water is recycled through settling tank and the settled moist marble dust is transported for disposal. Marble dust is a very fine powder has approximately 40% particles below 75µm diameter of which approximately 30% are having a size less than 25µm. Specific gravity of slurry is in the range of 2.70-3.00 gm/cm^3 with 5-20% water content.

The calcite marble rock of Makrana has calcium oxide & magnesium oxide in the range of 39-47% & 4-8% respectively. The dolomite rock of Rajsamand, Kishangarh and Udaipur regions has CaO & MgO in the range of 26-44% and 16-22% respectively.

Physical Characteristics

Characteristic	Property
Form	Fine powder
Colour	Off white
Shape	Angular
Particle Size (µm)	<45 -300
Particle Density (g/cc)	2.70 – 3.00
Bulk Density (g/cc)	0.9 – 1.4
Loss on Ignition	23-35%
Moisture (%)	5-20 %
Mineralogy	Dolomitic lime, Silica

Chemical Characteristics

	Kishangarh	Rajsamand	Udaipur	Makrana
SiO_2%	4.98-8.42	6.80-10.24	8.5-11.2	4.2-10.2
Al_2O_3 %	0.52-0.88	0.40-1.0	0.52-1.10	0.35-1.64
Fe_2O_3 %	0.4-0.6	0.5-1.1	0.40-0.94	0.44-0.92
CaO %	29.6-44.0	28.4-42.0	26.4-40.2	39.4-47.4
MgO %	18.0-22.10	16.2-21.8	17.4-21.8	04-8.0
Moisture %	10-19	8-21	8-18	7-22

Courtesy: ACC Cement, Lakheri, Kota

7. Current Status of Marble Slurry Disposal

Earlier, the marble slurry generated through processing units was collected improperly & dumped at any abandoned land and near the roadsides. This kind of practice is still going on near to Chittorgarh, Nimbahera, Neemuch & Shahpura (Alwar) areas. However, due to Government orders on control of environmental pollution & public awareness, these kinds of activities have reduced & now the local Marble Associations have identified the disposal sites and the generated slurry is being disposed through tankers at identified sites without spilling out on roads. The current statuses of slurry disposal practices are as under:

Kishangarh

Kishangarh district is having 523 marble gangsaws and 28 granite cutters in operation. Approximately slurry generation is 5500-6000MT per day. The generated slurry is being transported through tankers (capacity 4000 litres) to the Rajasthan State Industrial Development & Investment Corporation Ltd. (RIICO) notified disposal site. Daily 2000-2200 tankers are engaged in slurry disposal.

Kishangarh Marble Udyog Vikas Samiti has developed a dumping yard (Phase-I) in year 2005-06 of about 322 bigha area of 30-35 feets depth. The decanting wells are also provided and decanted water is recycled to gang saw units. This yard was designed to fulfill the 05 years of dumping requirement. Another site near to this yard has already been developed dumping yard phase-II in 532 bigha area to switch the dumping at this site.

The Kishangarh Marble Udyog Vikas Samiti and Kishangarh Marble Association have taken up very effective steps towards the dumping/disposal of marble slurry. Penalties are being

posed on units who are dumping waste marble slabs & slurry anywhere in the town. However, the broken marble slabs (Krazzy) at dumping site are freely collected by the marble chip & tiling units.

Makrana

More than 421 marble processor, granite cutter, modern slab & tile processing units are in operation in this town. Many stone crafting units have also developed. About 939 querries & mines on lease/license are active in marble mining. The processed waste (slurry) is being dumped/disposed at unauthorized land near to the railway

crossing, Manglana, before entering in Makrana. The proper authorization is yet to be awarded by RIICO to Sangmarmar Vyapar Mandal & Industrial area Entrepreneur Association, Makrana to develop the dumping yard.

Rajsamand

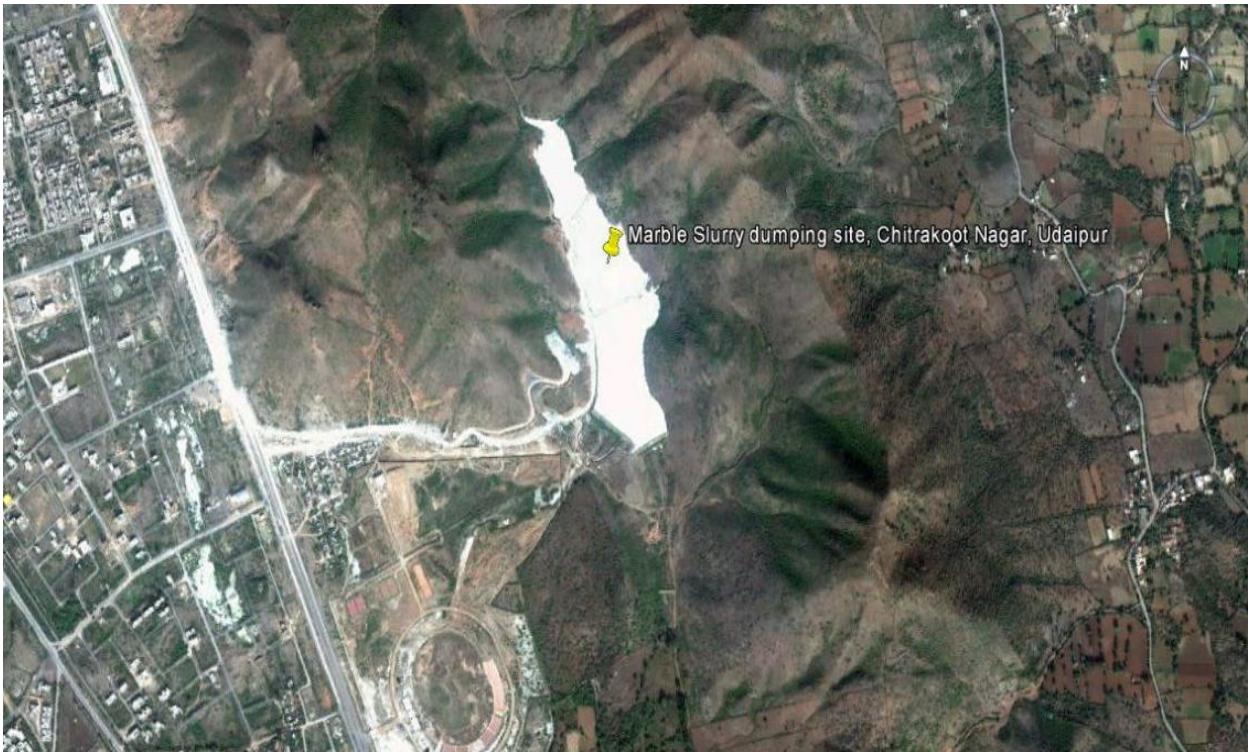
Rajsamand district of largest marble deposits has more than 250 modern gangsaws, 125 mineral grinders & 20-25 tiling units. Marble Gangsaw Association, Rajsamand has identified

& developed dumping yard is 250 bigha area near to the Nandora village. To avoid air pollution, huge plantation was done by the association; however the survival of the plants was found very poor. Other than slurry dumping at yard, it is being used as landfill in the low-lying areas. Minerals Grinding Plant Association, Rajsamand asked for 3,00,000 MT/year marble waste to replace the raw material requirement in grinding by 15-20% as a filler material.

Udaipur

Udaipur has over 100 Million Tons of marble deposits at around Babarmal, Rikhabdev, Masaron Ki Obri, Darauli, Tidi, Jaspura, Paduna, Manpur and Lohagarh etc. 600-700 queries/mines are in mining operation. About 135-150 Gangsaws in 100 marble processing

units & 20-25 marble tiling plants are in operation. Udaipur Marble Processors Association has identified a dumping yard at Chitrakoot Nagar near to Khelgaon & regular slurry



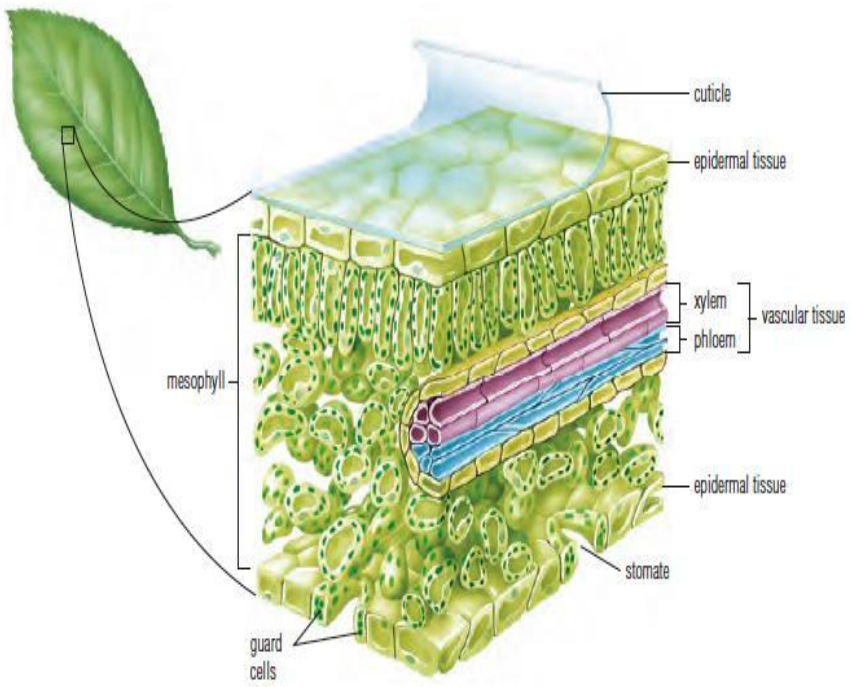
dumping/disposal is being done through tankers. This 30ft deep dumping yard needs to be raised upto 100fts high parapet walls to overcome the problem of slurry overflow during rainy season. Earlier the slurry was used to landfill the Khelgaon low-lying area.

8. Impacts of Marble Slurry Pollution

The existing disposal practices of marble slurry causing adverse impact on Ecology, Human health, Water & Air quality due to very fine particles (<45-300µm size) in marble slurry.

Ecological impact

- Reduced porosity & permeability of the topsoil along with the increasing alkalinity have tremendously affected the soil fertility. The percolation rate of rain water due to clogging of pores of top soil has also increased surface run-off which reduced recharging of ground water.



- Air blown, fine particle settles on epidermal layer of crops & vegetations & block the stomata's (responsible for plant respiration).

Air Pollution

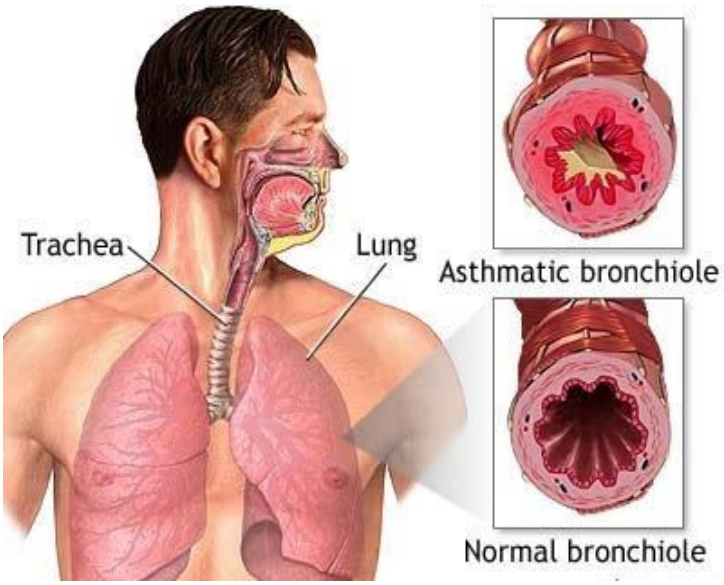
- Deposition of particulate/fugitive dust on roads upto 2-5cm causes emission of particulate matter due to vehicular activities and strong wind currents.
- Translocation of slurry dust affects flora & fauna of surrounding areas.

Water Pollution

- Disposing the slurry waste near to water bodies, road side areas can deteriorate the surface & ground water quality by increasing turbidity, suspended solids, calcium and magnesium hardness.

Health impact

- Continuous exposure to marble dust can cause severe respiratory disorders like Bronchitis, Asthma, Chronic Obstructive Pulmonary Disease (COPD) to the laborers.
- Dermal & eye irritation are most common problems in nearby population.



Noise Pollution

- The workers working near/on the processing gangsaw machine are get exposed to continuous noise level of 90-120 dB(A), this noise level can damage physiological & psychological human health.
- Increased noise level can cause annoyance & aggression, hypertension, high stress levels, hearing loss, sleep disturbances.

9. Marble Slurry Management

To access the slurry management options, a preliminary survey was conducted during 13th January to 23rd January, 2012 at Kishangarh, Rajsamand, Makrana, Udaipur and Chittorgarh regions of Rajasthan. The survey followed by an interaction meet on 'Marble & Marble Slurry Disposal: Problem, Issues & Probable Solutions' at Kishangarh (Rajasthan) organized on 28th February, 2012 along with the representatives of Marble Associations, Cement industries & marble processing units.

About 1100 marble processing units all over the Rajasthan are generating around 5-6 Million Metric Tons of slurry every year. To manage this huge inorganic & non-hazardous waste in gainful/productive use, options were explored. Discuss below various stages/options of utilization of marble slurry in detail:

Option No. 01 Utilization of marble slurry in cement manufacturing

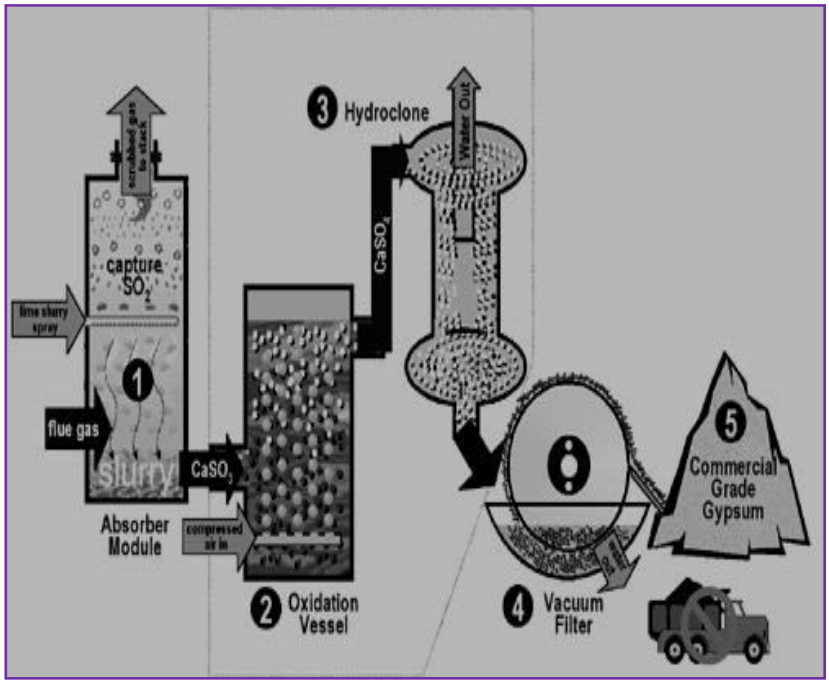
Rajasthan state has more than 18 cement manufacturing plants because of huge limestone deposits. The dolomitic marble slurry powder contains high MgO percentage therefore the cement manufacturers are not replacing raw material (Lime stone) with marble powder. The acceptable percentage of MgO in Cement manufacturing is in the range of 1-5%. The increased percentage of MgO in raw mix delays the hydration process as well as produce cracks. The percentage of moisture in raw mix required by cement plants is below 0.5-1% whereas in marble slurry it is in the range of 8-22%.

Region	Cement Manufacturer
Makrana	M/s Ambuja Cement Pvt Ltd
Kishangarh	M/s Shree Cement Pvt Ltd
Rajsamand	M/s J K Cement Pvt Ltd
Udaipur	M/s Binani Cement Pvt Ltd
Chittaurgarh	M/s Birla Cement Pvt Ltd
Abu Road	M/s J K Lakshmi Cement Pvt Ltd

M/s ACC Cement, Lakheri, Kota is using part of Makrana marbles slurry as the replacement of limestone because of the calcined nature of Makrana rock along with the low moisture percentage.

Through laboratory studies & modification in plant machineries the dolomitic, serpentine & other marble rock slurry can be used in cement manufacturing.

Option No.02 Synthetic gypsum through chemical reaction with marble slurry



Marble powder can be chemically convert in gypsum; however the percentage of MgO plays the important role here again. The higher the percentage of MgO in marble powder will convert in $MgSO_4$ & this sulphate form of magnesium will reduce the strength of cement.

Calcine marble powder can be used in producing synthetic gypsum due to low percentage of MgO. The technical possibilities are being explored by Centre for Development of Stones (CDOS), Jaipur. M/s Ambuja Cement, Rabariyabas, Pali is also exploring the technical aspects to overcome the problem.

Option No. 03 Utilization of Marble slurry dust (MSD) in road construction

Shri A K Misra, Scientist 'F' of Central Road Research Institute (CRRI), New Delhi has successfully demonstrated the marble slurry based road construction of 750 metres stretch on 05th March, 2006 at Kuncholi village, Rajsamand. It states that sub-grade layer of a road pavement can be constructed by ameliorating in-situ soil

Cost Benefit Analysis for Single Lane Pavemant
(3.75 m carriageway, 1.0 km long)

Soil requirement for sub-grade preparation (600 mm height) = 5000 m^3
MSD requirement (20% by wt of soil)
= 1000 m^3/ 1900 tonne

Saving in sub-grade soil using MSD
= 1000 m^3
Cost of this soil
= 1.0 Lakh

Extra cost for mixing of MSD & soil + lead & lift (10 km), mixing with JCB
JCB charges/ day [mixing capacity (300 - 400 m^3/d) @ Rs. 2/- / m^3] = Rs 600/-
Mixing cost = Rs 10,000/-; transportation (lead & lift) = Rs 15,000/-
Total = Rs 25,000/-
Net saving = Rs 75,000/-

with 20-35 % of marble slurry dust. Estimated savings per kilometers of a single lane road sub-grade with 20% of marble dust is about Rs. 75,000/-. It also can be utilized for raising embankments & as a filler material. The 5-6 Million MT generation of slurry per annum can be consumed in construction of 2500-3000 Kilometers one lane road.

State Public Work Department (PWD) needs to approve this mixer to allow in road construction.

Option No.04 Utilization of Marble slurry as a Low Cost Binder

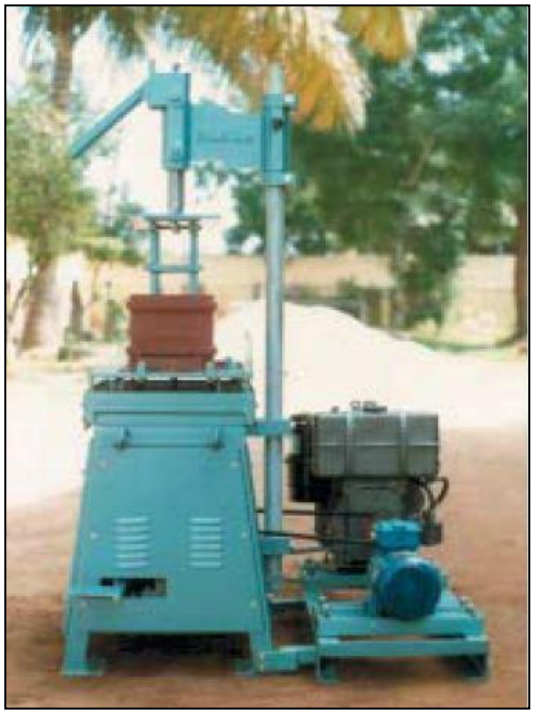
Shri Sampat Lal Surana, Mechanical Engineer has patented (Indian patent no. 189030) technology to use marble waste as a low cost binder. Building Materials & Technology Promotion Council (BMTPC), Ministry of Housing & Urban Poverty Alleviation, Govt of India has also awarded a Performance Appraisal Certificate (PAC) under third party operated voluntary scheme PACS. The physical characteristics required in building materials as per IS: 3466-1988 are satisfied by this Low Cost Binder: sand ratio (1:3). Binder has also included in Basic Schedule of Rates (BSR) of Udaipur, Rajsamand, Nagaur, Ajmer and Jaipur circle of Public Work Department (PWD), Rajasthan for non-load bearing structures only at chapter stone masonry, brick masonry & plaster work.

S.No.	Characteristics	Requirement as per *IS: 3466-1988*	Required as per PWD Table	low cost binder
1	Fineness residue on 45-micron IS Sieve, Max %	15	----	4.00
2	Setting Time Initial ,Min Final, Max	 90 min 24hrs	 -----	 4 to 8hrs 18 to 22hrs
3	Soundness Le-chatelier expansion, Max Autocative expansion	 10mm 1 percent	 -----	 4.85mm 0.082 percent
4	**Compressive strength:** Average compressive strength of not less than 3 mortar cubes of 50mm size, composed of one part masonry cement / low cost binder and 3 parts standard sand by volume, Min in (**kg/cm²**) **7 days** **28 days**	 25 50	 15 30 to 50	 15 to 22 30 to 66
5	**Water Retention:** Flow after suction of mortar composed of 1 part masonry cement / low cost binder and 3 parts standard sand by volume, Min	60 percent of original flow		30 percent of original flow

This binder can be approved to construct the surrounding walls as well as a partial replacement of the cement.

Option No.05 Utilization of marble slurry in brick manufacturing

Results of Central Pollution Control Board (CPCB) & The Royal Norwegian Embassy (NORAD) sponsored project to



Physical characters	Traditional bricks	Marble slurry bricks
Color	Red	Off-white
Size	210*95*70mm	225*100*75mm
Volume	1396.5cm^3	1687.5cm^3
Compressive strength	30-40 kg/cm^3	93 kg/cm^3
Water absorption	19%	14%

Indian Environmental Society, Delhi states that marble bricks (83% slurry + 7% cement + 10% construction sand) has 93 kilo/cm^2 compressive strength that is 2.5 times more than the traditional red bricks also due to non-inflammable & inorganic raw material, marble bricks are fire resistant. Electricity as energy source & water as curing of bricks reduces the air pollution & saves the natural energy sources (coal & fuel wood).

Option No. 06 Utilization of marble slurry powder in mineral grinding plants

Marble powder mix with other grinded minerals can also be used in ceramic manufacturing. The feldspar, soda & quartz mineral grinding unit requires mixing 15-20% of marble powder as a filler raw material. On an average, Rajsamand's mineral grinding units require 3 lakh MT of marble waste every year as a filler raw material. The grinding units of Kishangarh, Rajsamand, Makrana, Udaipur and other marble process region can utilize a large quantity of slurry in productive manner.

Chips & tiles manufacturing units of Morvi, Gujarat are using marble mine & process rejected broken slabs in large quantity.

M/s J K White Cement Works, Nagaur & M/s Birla White Cement are using calcitic marble waste in manufacturing of white putty.

10. Impact of 'Paryavaran Darshan' program

Central Pollution Control Board sponsored weekly program 'Paryavaran Darshan' to regional Kendra of Doordarshan. Two episodes were prepared on 'marble slurry waste disposal options' by the Regional Kendra- Jaipur.

First episode covered the whole marble mining, processing to slurry waste disposal activities of Kishangarh, Makrana and Rajsamand area along with the public opinions. The episode was telecasted on 25th February, 2012.

The second episode covered the interaction meet organized by CPCB, Zonal Office-Bhopal on 28th February, 2012 along with the representatives of Marble Associations, Cement industries, mining department. The episode was telecasted on 3rd March, 2012.

Both the episodes were highly appreciated by the viewers. This program played an important role in awaring the masses on sensitive environmental issues.

A DVD having both the episodes is enclosed with this report.

11. Recommendations to overcome the environmental problems:

Earlier marble processing units were listed under orange category in Rajasthan State Pollution Control Board (RSPCB); now these marble processing units are categorized under Red category industries (Small/medium/large) vide office order No. F. 14 (57) Policy/RPCB/Plg/9219-9259 issued on 21.12.2010. Due to clogging of aquifers & contamination of groundwater along with the increasing level of air pollution RSPCB revised the industrial/process/projects categorization.

- To direct Central/State PWDs through notification to use the marble slurry in road construction as a filler material as well as in construction of low load bearing walls.
- To subsidies the installation of 'Low cost binder technology' along with the brick manufacturing units.
- To have the Bureau of Indian Standard's (BIS) approval for using marble slurry powder as an additive in cement manufacturing.
- To submit the time bound action plan on 'proper marble slurry disposal & recycling' by marble associations to RSPCB.
- To direct State government to make the marble broken slabs royalty free.
- To develop the marble processing area a lush green through green belt development.
- To develop the guidelines of proper marble slurry disposal by CPCB.
- To install filter press in gangsaw units commonly as well as provide facility for drying the slurry upto the required moisture limit of cement manufacturers.
- To install the continuous ambient air quality monitoring system (CAAQMS) in marble processing regions.
- To conduct an occupational health checkup in marble mining & processing units under private-public partnership mode.
- To install water sprinkling systems at identified locations to improve the housekeeping of industrial area.
- To direct RIICO & marble associations to develop infrastructure like roads & drainage system etc.