MANAGING WASTE FOR ECOLOGICAL BALANCE

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Abstract

Industrialization and economic growth has produced more amounts of waste, including hazardous and toxic wastes. There is a growing realization of the negative impacts that industrial wastes have on the local environment air, water, land, human health etc. and ecology. As the marble industry grew up in early eighties, the new industry was welcomed by all sectors of society with the hope that there will be prosperity, employment, market upliftment and industrialization of the region. The expected results were also seen for few years but environmentalists soon realized the problems and drawbacks of the much liked industry. The problem was the ecological and environmental imbalance caused by the waste generated in mining and processing by the snow falling numbers of the mining and processing units in Rajasthan**.** Eco- friendly practices for managing waste to maintain ecological balance is the need of the hour both for developed and developing nations, for urban and rural areas, and for residential and industrial producers. Waste management is the collection of all thrown away materials in order to recycle them and as a result decrease their effects on our health, our surroundings and the environment and enhance the quality of life. The paper is outcome of the research study done in the selected mines of the Rajsamand area of southern Rajasthan region. The study explains dimensions of the waste generated in mining of marble and has identified the impact on surroundings as well as techniques to minimize the waste for ecological protection.

Key words: Industrialization, **Environmental imbalance, Waste management**

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Introduction

Every industry whether it is a mineral industry i.e. mining, processing or production industry necessarily generate some waste during its production. The big industry sometimes creates a new cottage industry out of its waste and In year 2012-13, Rajsamand area has; 1133 marble mines, 1378 Hectares of area of marble mines, 70.4394 Lacks Tons production of marble and Rs.143.3665 lacks of revenue and having manpower about 12500 employees .(DMG Rajasthan, Website)

Commercially marble is a crystalline rock composed predominately of calcite, dolomite, or serpentine that hardness of 3 to 4 on Mohs scale and capable of taking good polish. Chemical impurities may be present in marble in the form of Silica (SiO_2) as free quartz or silicates, iron oxides as hematite (Fe_2O_3), Limonite ($2Fe_2O_3.3H_2O$), Manganese oxide (MnO_2), and Alumina (Al_2O_3) in form of aluminum silicates. Presence of impurities generally imparts decorative patterns and colors to marble.

Waste Management

Waste management includes minimization, disposal and reutilization of the waste generated in mining and processing of marble. Waste Management flows in a cycle: monitoring, collection, transportation, processing, disposal or recycle. Through these steps a company can effectively and responsibly manage waste output and their positive effect they have on the environment.

Waste management is a multi-disciplinary activity involving engineering principles, economic, urban and regional planning, management techniques and social sciences, to minimize the overall hazardous activity of the system under consideration. The term usually relates to all kinds of waste, whether generated during the extraction of raw materials, the processing of raw materials into intermediate and final products, the consumption of final products, or other human activities. It is intended to reduce the effect of waste on health of the environment .The waste hierarchy refers to the "3 Rs" reduce, reuse and recycle, which classify waste management strategies according to their desirability in terms of waste minimization. The aim of the waste hierarchy is to extract the maximum practical benefits from products and to generate the minimum amount of waste

Types of marble waste

The marble waste generation during extraction of marble blocks can be estimated at 30 % to 40 % of the production (in mechanized mines using methods such as wire saws) and at 60 % to 70 % in mines using conventional techniques of blasting. This waste includes odd blocks of various sizes and shapes, unwanted blocks and rock fragments produced during trimming and shaping of mined out blocks before dispatch to processing units. This leads to uncontrolled stripping of vegetation cover and subsequent soil erosion. Dust generated during quarrying can also blanket surrounding areas leading to vegetation die-off and adversely affecting the fertility and quality of top soil. While marble waste may be useful in many industries, but is needs economic considerations.

Unlike any other industry / mining, any dimensional stone industry produces large amount of waste, in terms of small blocks, small tiles, or broken tiles etc., (Indirect waste) along with the normal processing waste (Direct waste). These indirect wastes are from total reserves itself which were designated to produce much higher revenue but only giving small due to small sizes of product.

As far as marble waste is concerned many scientist and researcher have classified the waste generated in mining and processing into following categories. For the purpose of understanding and differentiate the generated waste we can further divide the waste into two broad classes;

Mining/Quarry Waste:

The main causes of quarry waste include;

(i) Removal of top soil; since it is an initial work of mine development is necessary to remove the top soil to expose the rock of marble or another rock of overburden. Generally it removed in initial stage and stacked at the nearest place to mine re-handled at later stage for proper dumping. The methods employed for topsoil removal varies widely, depending on the size of the quarry and the capability and inclination of management for reclaiming the land. In the process of top soil removal a certain quantity of marble is wasted in blasting operations

(ii) Removal of overburden; the next step in open cast mining is to expose the rock or marble by removing the overburden. The thickness of overburden may be any from zero to several meters. This thickness decides the method of its removal and also decides the profitability of the business and initial investment in the project. Overburden usually comprises of

weathered rock, embedded or scattered boulders of various sizes, rubble etc. Drilling and blasting is frequently needed to blast the rock portion. The good quality boulders could be utilized for producing blocks. Other weathered portions of rock rubbles etc are stacked in relevant place. This work is the main potion of the waste generation.

(iii) Production of marble; in the production of marble, benches are formed and a considerable amount of waste is generated during this stage. Moreover waste is also generated in formation of roads, ramps and other development works in benches. Extraction of blocks also generates waste in sizing blocks and resizing of big blocks, if necessary.

Processing Waste

The processing waste, as termed as direct waste above, is the result of slabing, sizing and polishing operations. During these operations, a groove, of the width of cutting tool and length of block / slab is converted into the waste (slurry.) In the gang sawing, after each slab thickness (8/18 /20 mm) there is a groove of 5 mm thickness (sawing thickness) i.e. in one block 62 (in 62 blade gang saw) grooves are cut for entire length and breadth.

The waste produced of processing of marble is of direct type, i.e. produced, as a by-product of the operation, thus only having any depleted secondary use. Various types of waste generated during processing of marble are: (a) Cutting waste (b) Polishing waste and (c) Handling waste. In addition to this the forms processing waste may include Slurry (due to dust from cutting, carving and polishing operations), Rejected pieces /chips resulting from final cutting of usable tiles or slabs of desirable dimension (commonly termed as crazy) and Chips and small pieces, resulting from carving etc. Dressing waste is also a form of waste in processing in which waste is generated in dressing of the irregular slab or tile dressed to regular size before initial process of tiling.

The slurry generated during processing is estimated to be about 10% of the total stone quarried (20% to 25% of the block as received from the quarries) and during polishing as 5% to 7%.

Mining waste minimization

The method of mining should be adopted in such a way the mining waste in zero mining waste is generated or at minimal quantity. At present the mining waste is approximately 50% of the handled rock mass of marble. This is all due to working with traditional system of mining with **Phada** system in which a huge block of marble is dislodged from insitu rock and the separated into transportable blocks. This is normally done with light explosive. This practice generates

most of the waste in mining. Instead of this bench height should be kept as per maximum size feed to gang saws (i.e. 10 ft. High), this will reduce direct waste. Deployment of modern wire saw, derrick crane and block handlers will reduce the waste at respective stages in mining.

Mining waste and modes of proper disposal

Mining Waste is mainly generated in initial opening of mining pit as removal of overburden, development of opening **Gullies** and clearing of top soil to expose the main rock of marble. As the waste disposal in mining is a very tedious, energy and money consuming operation. The natural cracks present in the strata also generate the major part of the mining waste. The waste so minimize should be disposed at the place nearest to the mining area to minimize the transportation cost. But care should be taken that the disposal site should not degrade the ecological and environmental condition of the vicinity. The waste should be disposed off very scientifically to minimize the impacts at the demarked site for the disposal by government. The site may be at an average distance of a particular cluster of mines, maintained on NGO, Governmental or Mines Association Level. The top soil of the dumping yard be protected and be used after the dump for plantation to get re- vegetating of pre- dump condition. A perfect method cannot be devised for proper disposal but some of the suggestions as the mining sites vary from place to place but disposal can be improved with better infrastructure facility like roads. In case of mine dumps, the height, area and shape of the dump should be designed as per the land available. The completed surfaces of dump should be stable and able to resist long-term erosion. The designed land construction of the waste dumps should be such that the completed out slopes do not exceed 20^0 from the horizontal. Drainage should be constructed to handle heavy rainfall events. Handling and disposal of the quarry waste in an environmental friendly manner is the primary concern of the quarry owners. Realizing the urgent need for conservation of land and an environmental friendly system of disposal of quarry waste and enhance return of the reserves.

Processing Waste Minimization

The researchers so far have concluded that processing of marble at block dressers, gang saws and tiling plants is in order of about 20%, gang sawing waste and further 10 to 20% of handling and other wastes depending upon the output block geometry and total production. The 20% of gang sawing waste is in forms of slurry, which is absolutely dependent upon the size of groove. For the minimization of these waste, experiments for reduction of groove size is required and beyond the scope of the study. Minimization of this 20% can only achieved by this option only, but

overall minimal waste can be achieved by performance enhancement of the operations. Also the additional waste of 10 to 20% is solely dependent upon the output quality of mining, transporting and processing. Well maintained alignment of the machine as well decreases the generated waste with better cutting of the stone.

Processing waste disposal

The processing waste is generally slurry, which is a by product of sawing of marble on gangsaws, wiresaws, block dressing machine and wheel cutters. The marble powder mixed with water in cutting makes the slurry. The slurry disposal sites should be far from human settlements. Proper care to be given to it as compared to mine waste, since its ingredients are fine, which after air borne create lots of problems of environment and human health. Water should complete be taken out from slurry and thus only cake should be disposed off. The slurry may be used to level up the undulating farming land after conserving the top soil and later on top layering on the levelled ground to improve efficiency of farming. The slurry should be used in low profile surface for filling and prior to that top soil be preserved for top laying after levelling the ground and converting the land cultivable to protect ecology and environment.

Mining Waste Reutilization

It is necessary to minimize the mining waste as it true that we cannot zero the waste in mining. So we can utilize the generated waste by its value addition by transforming the shape and size of the waste to some marketable products e.g. small idols, tableware, flower pots etc. Mining waste generally comprises of overburden, small pieces of marble and top soil. The overburden can be utilized in building construction or may be dumped to the nearest place to mines for its use in future for back filling or reclamation (Filling of mined out area). Far away dumping may be uneconomical and may not be adopted by private small scale mine owners. The small pieces may be used for filling the voids in mining operations. Use in quarry boundary and other walls. Small pieces can be used for construction of houses, offices etc nearby, use in construction of waste/reject dams, use in construction of retaining walls and embankments etc. The mining waste may be reutilized with implementation of rules and on cluster basis the initiating may be taken by social working societies for awareness to reutilize the waste.

Processing Waste Reutilization

The processing operation of marble industry produces approximately 20% of the input in terms of marble powder. This is resulting in huge quantity. It consumes lots of energy and money to properly dispose off. But the environmental people have objected it strongly and the industry has been forced to think of its proper disposal and reutilization of this menace. So many organizations, NGO, association and government bodies have worked for its gainful reutilization. The common line of research was to prepare bricks from the slurry in light of huge quantity to be reutilized. They have prepared and tested a lot of combinations of cement, sand and marble slurry dust (MSD) mixtures and inferred very positive results; that they are better than conventional, in terms of look, strength and glaze and above all, consumes waste. Many experiments have been published and efforts have been made to utilize the marble slurry dust in various industrial products.

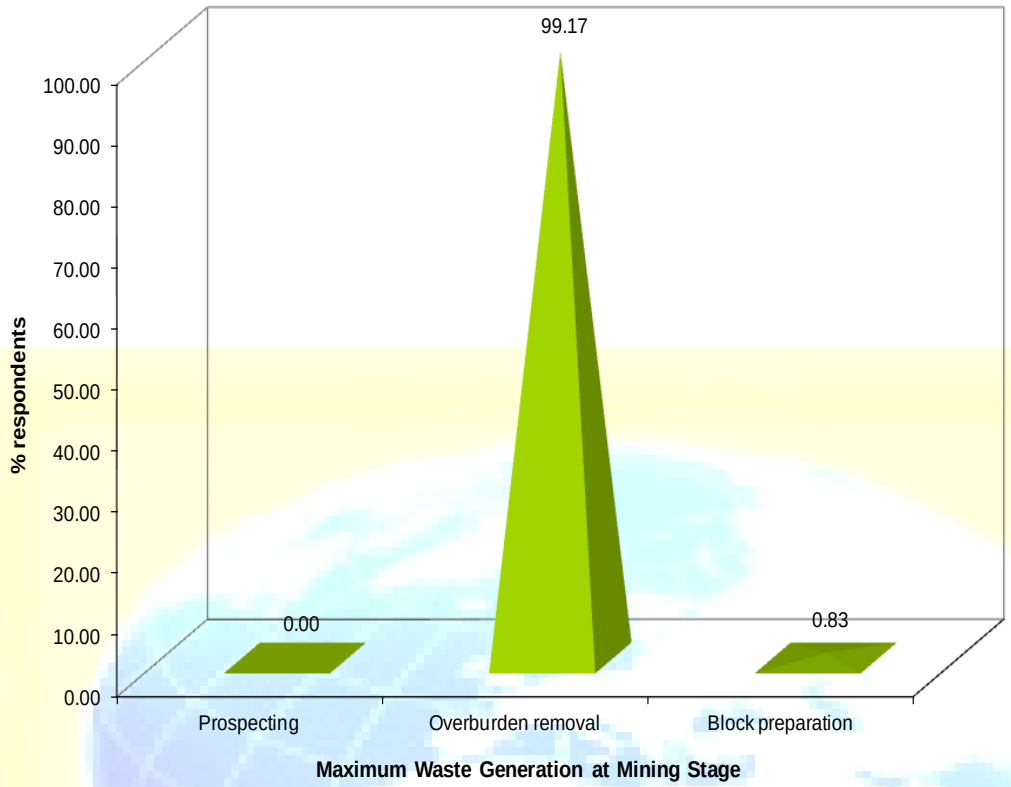
Research Study:

A research study was done at 120 mines of the study area a schedule format was prepared and responses were recorded. Based upon the responses analysis was carried out and following results were found out.

Table 1: Stage of mining at which waste generation is maximum

Location	N	%
Prospecting	0	0.00
Overburden removal	119	99.17
Block preparation	1	0.83
Total	**120**	**100.00**

Graph 1 Stage of mining at which waste generation is maximum

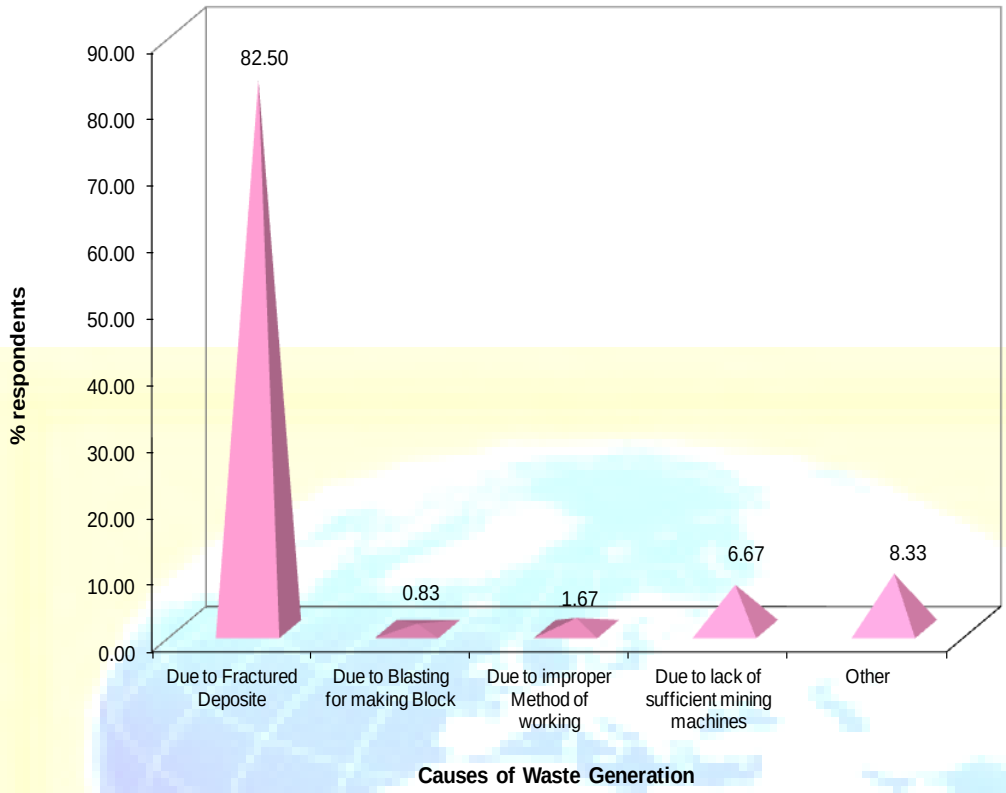


Almost all respondents are in the view that overburden removal is the only stage in mining when maximum waste is generated.

Table 2: Cause of generation of waste

Causes	N	%
Due to Fractured Deposit	99	82.50
Due to Blasting for making Block	1	0.83
Due to improper Method of working	2	1.67
Due to lack of sufficient mining machines	8	6.67
Other	10	8.33
Total	**120**	**100.00**

Graph 2: Cause of generation of waste

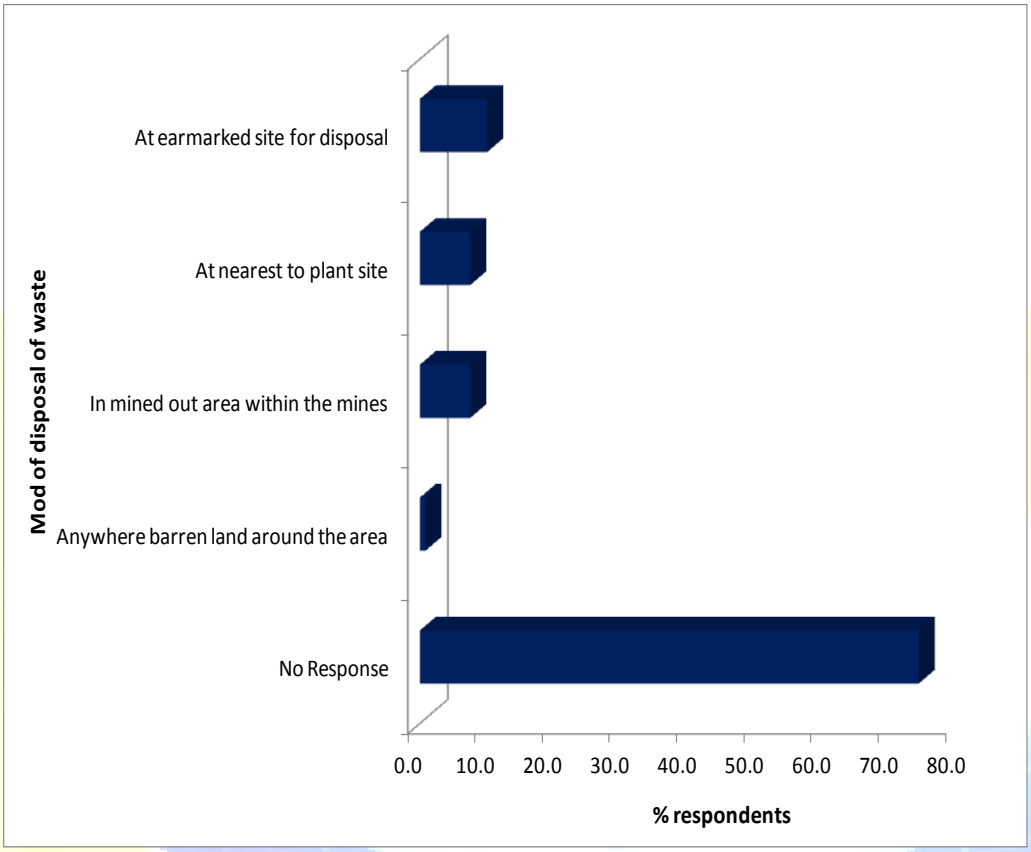


The main cause of waste generation of waste is fractured deposit; nearly 82.5% mines owners realized that this is the major cause of waste generation in marble mining. Remaining respondents replies with unremarkable answers.

Table 3: Mode of Disposal of waste

Response	N	%
At earmarked site for disposal	12	10.00
At nearest to mine site	9	7.50
In mined out area within the mines	9	7.50
Anywhere barren land around the area	1	0.83
No Response	89	74.17
Total	**120**	**100.00**

Graph 3: Mode of Disposal of waste

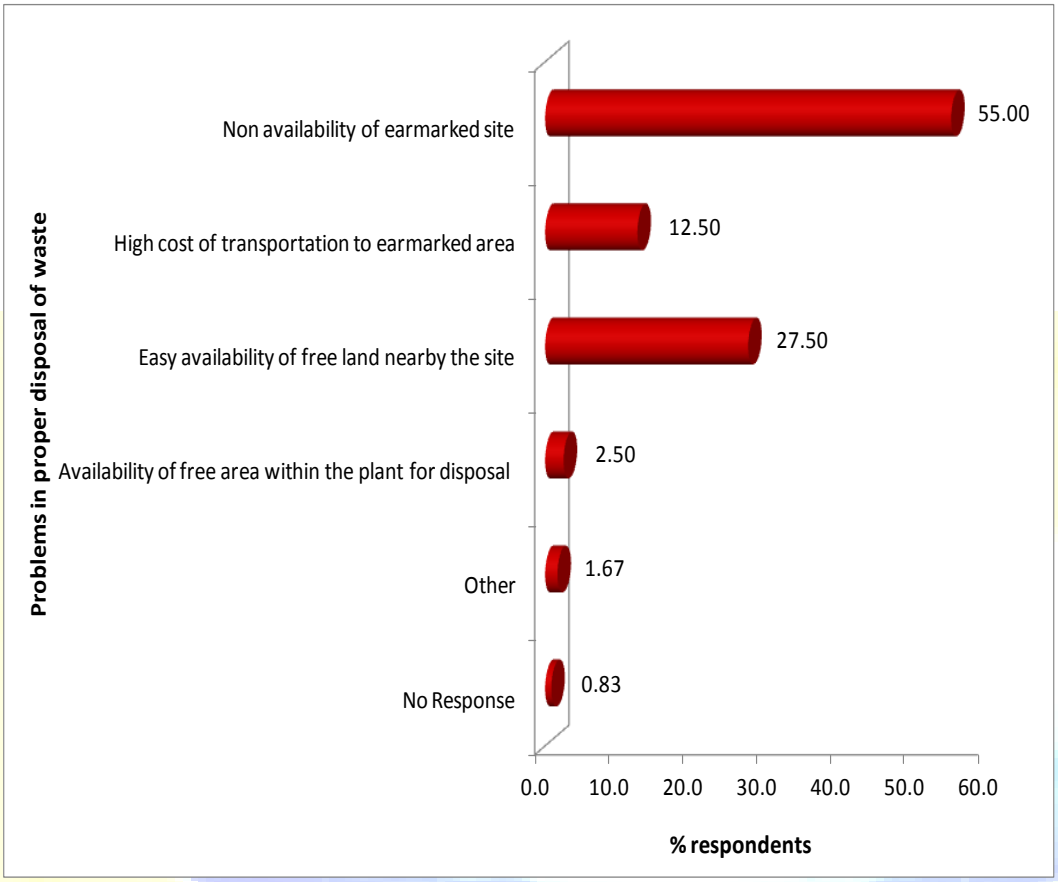


74% of the respondent kept silent on this important question regarding mode of disposal of the waste and 10% accepted to dispose it on earmarked site which clears that waste is not disposed off in productive ways which hampers the environment.

Table 4: Problem in proper Disposal of waste

Response	N	%
Non availability of earmarked site	66	55.00
High cost of transportation to earmarked area	15	12.50
Easy availability of free land nearby the plant site	33	27.50
Availability of free area within the plant for disposal	3	2.50
Other specify	2	1.67
No Response	1	0.83
Total	**120**	**100.00**

Graph 4: Problem in proper Disposal of waste

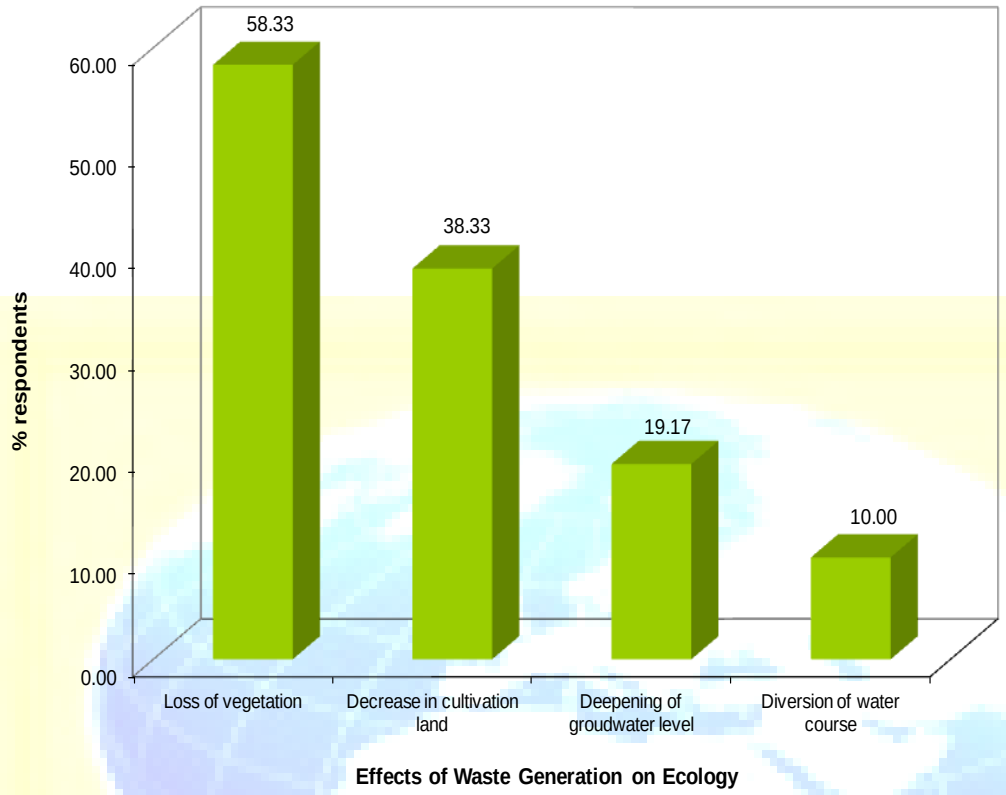


55 % of the respondent realized the most important problem is non availability of the earmarked site near their mines, more than 27 % accepted that free dumping land is available near their site. 12.5 % found high cost of transportation of waste to earmarked site.

Table 5: Effects of waste generation on ecology

Response	N	%
Loss of vegetation	70	58.33
Decrease in cultivation land	46	38.33
Deepening of groundwater level	0	0.00
Diversion of water course	0	0.00
Other specify	0	0.00

Graph 5: Effects of waste generation on ecology

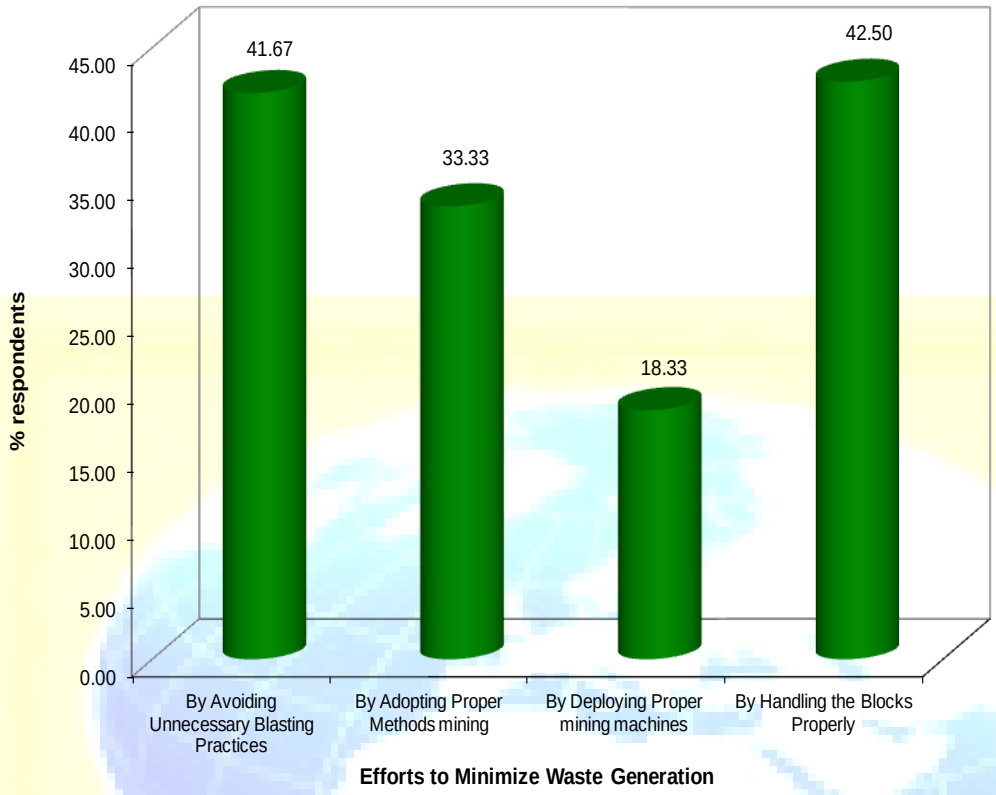


The main effect of waste generation on ecology as responded by 58.33% respondents is loss of vegetation and 38.33% say that it decreases the cultivating land.19.17% of the respondents of the mines under research study reported it as deepening of ground water as an effect of waste generation. However 10% are in opinion of diversion of water course as an effect of waste generation.

Table 6: Efforts made to minimize waste generation

Response	N	%
By Avoiding Unnecessary Blasting Practices	50	41.67
By Adopting Proper Methods mining	40	33.33
By Deploying Proper mining machines	22	18.33
By Handling the Blocks Properly	51	42.50

Graph 6: Efforts made to minimize waste generation

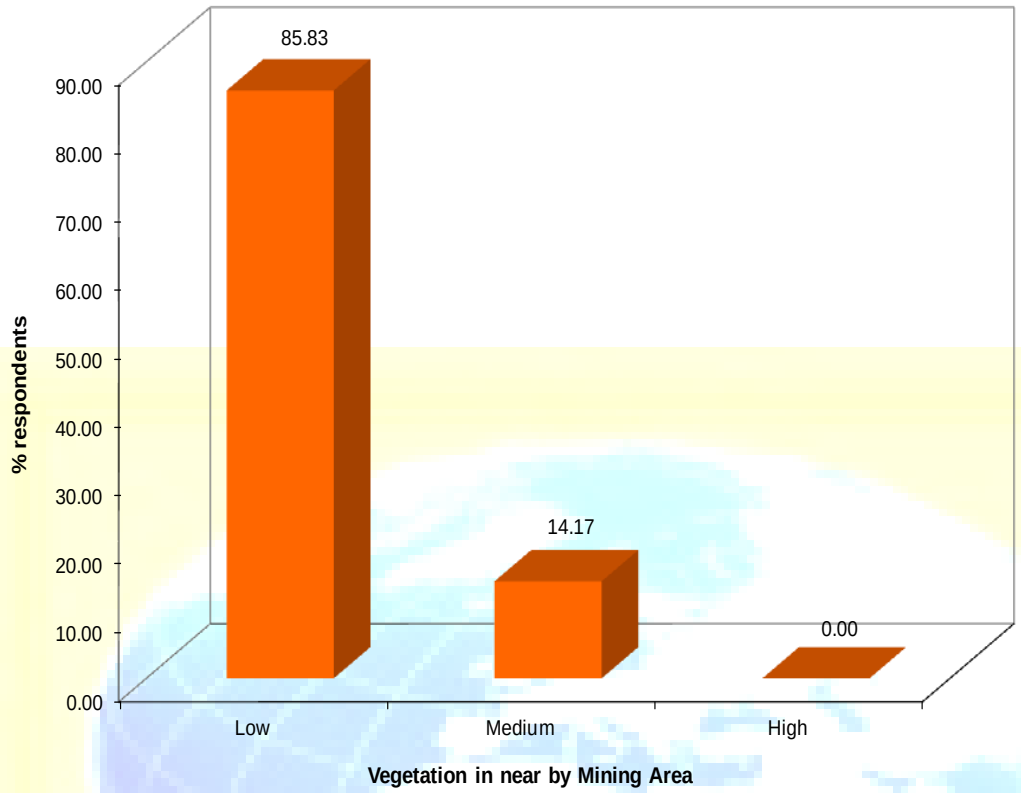


Proper care taken in handling the blocks can reduce the waste to great extent as reported by 42.5% respondents. 41.67 % say that waste can be minimized by avoiding blasting practices in marble mining, 33.33 % are in the opinion that waste can be minimized by adopting proper mining methods. 18.33 % relieved that proper use of mining machines can also reduce generation of waste to a great extent.

Table 7: Present situation of vegetation in nearby mine area

Response	N	%
Low	103	85.83
Medium	17	14.17
High	0	0.00
Total	**120**	**100.00**

Graph 7 : Present situation of vegetation in nearby mine area

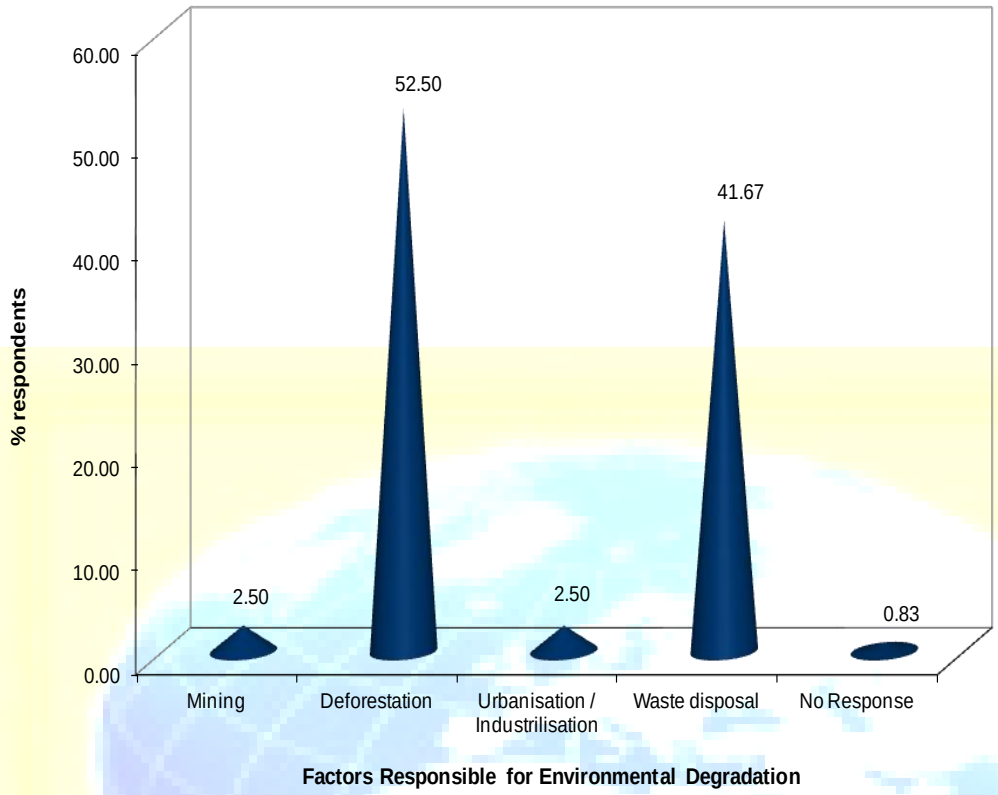


More than 85 % of the respondents reported about the situation of vegetation to at low existence in the mining vicinity. About 14 % observed as medium situation of vegetation in the mining sites. Nobody answered as state of high vegetation of their mining area.

Table 8: Factors responsible for environment degradation

Response	N	%
Mining	3	2.50
Deforestation	63	52.50
Urbanization / Industrialization	3	2.50
Waste disposal	50	41.67
No Response	1	0.83
Total	**120**	**100.00**

Graph 8: Factors responsible for environment degradation

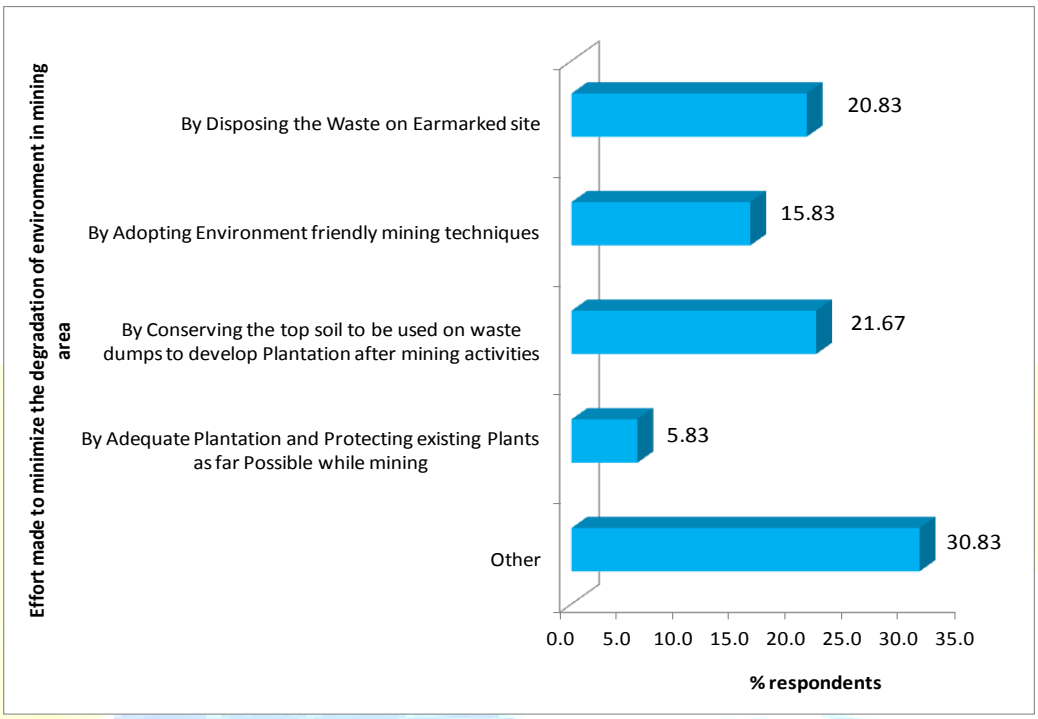


Less than 3% mine operators are in the opinion as mining to be responsible for environmental degradation.52.5 % Mining people claimed deforestation to main cause of this degradation. However 41.57 % of the respondents were in the view that waste disposal was also a cause of environmental degradation.

Table 9 Effort made to minimize the degradation of environment in mining area

Response	N	%
By Disposing the Waste on Earmarked site	25	20.83
By Adopting Environment friendly mining techniques	19	15.83
By Conserving the top soil to be used on waste dumps to develop Plantation after mining activities	26	21.67
By Adequate Plantation and Protecting existing Plants as far Possible while mining	7	5.83
Other	37	30.83

Graph 9: Effort made to minimize the degradation of environment in mining area

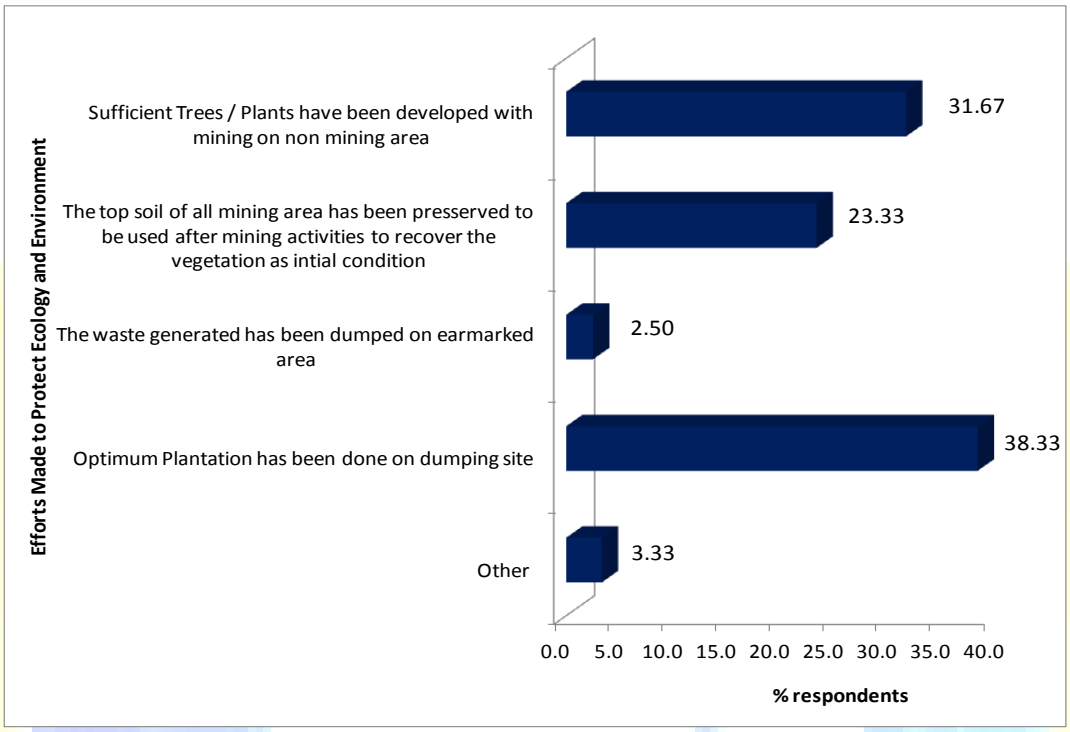


There was quite mixed opinion of the representative at the mine regarding efforts made by them to minimize the degradation of environment in vicinity of their mines. 21.67 % relieved that they conserve top soil to be used on waste dumps to develop plantation after mining is over, about 21 % told that they minimize the degradation by disposing the waste at earmarked site for this, 15.83 % do this by adopting environmental friendly mining techniques. Lager portion about 30 % were making other efforts to minimize the degradation of the environment.

Table 10: Efforts made to upgrade / protect ecology and environment by utilizing the waste at mining site

Response	N	%
Sufficient Trees / Plants have been developed with mining on non mining area	38	31.67
The top soil of all mining area has been preserved to be used after mining activities to recover the vegetation as initial condition	28	23.33
The waste generated has been dumped on earmarked area	3	2.50
Optimum Plantation has been done on dumping site	46	38.33
Others	4	3.33

Graph 10: Efforts made to upgrade / protect ecology and environment by utilizing the waste at mining site

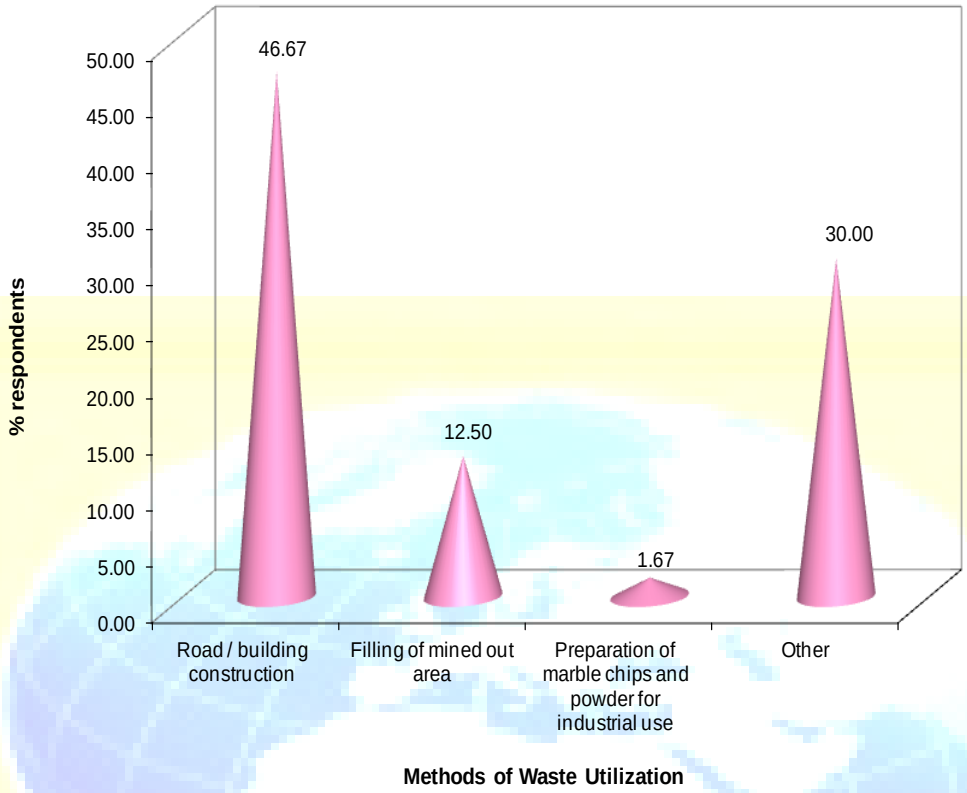


Various efforts have been made by the mines owners of the research area.38.33% mine owner have done optimum plantation on dumping site to enhance vegetation in area. 31.67 have planted sufficient trees in mining and non mining area.23.33% of the respondents have preserved the top soil to be used afterwards the mining activity is over to grow vegetation in mined out area.

Table 11: Various methods of waste utilization

Response	N	%
Road / building construction	56	46.67
Filling of mined out area	15	12.50
Preparation of marble chips and powder for industrial use	2	1.67
Other	36	30.00

Graph 11: Various methods of waste utilization



More than 46% mine owners of the research area utilize the waste in road and building construction.12.5% use the waste in filling the mined out areas. Whereas 30.00% adopted other methods to utilize the waste generated in mining.

Hypothesis I

H_{01}: There is no loss of ecology by waste generated in marble mining.

H_{A1}: There is significant loss of ecology by waste generated in marble mining.

Proportion of respondents agreed that there is loss of ecology in one way or another due to marble mining which is statistically tested further using Z test.

N	P	SE	Z	Result
120	0.9833	0.012	32.76	***

Test results given above show that Z value is highly significant this compelled us to reject null hypothesis that there is no loss of ecology by waste generated in marble mining.

Hypothesis II

H_{02}: There is no degradation to environment due to waste generated in marble mining.

H_{A2}: There is significant degradation to environment due to waste generated in marble mining.

On the basis of data collected from the marble mine operators, the main reason(s) given for degradation of environment were deforestation and waste disposal but they do not agree that environmental degradation is due to marble mining. Only negligible fraction of respondents agreed that environmental degradation is due to mining and rest around 97.5% denied to this fact.

High proportion of respondents agreed that the environmental degradation is not due to mining but due to deforestation and waste disposal which is further statistically tested using Z test.

N	P	SE	Z	Result
120	0.025	0.0143	1.78	NS

Test results given above shows that Z value is non-significant ($p > 0.05$), which compelled us to accept null hypothesis. Hence the null hypothesis is accepted that there is no degradation to environment due to marble mining and alternative hypothesis is rejected which proves that marble mining is not degrading the environment.

Conclusion

It is evident from the analysis that loss of ecology is not due to mining activity in the research area, proven from test applied on the data collected. Necessary measures to reduce the damage to environment and ecology of the mining area for waste disposal and vicinity need to be taken to go a long way to better the quality and management of the environment in marble mining sector.

Hypothesis II proved that the environmental degradation is not due to mining but due to deforestation and waste disposal. By adopting proper mines waste disposal methods this can be checked. Better technique of mining with least blasting and deployment of mining machineries is adopted so as least waste is generated in mining operations. Proper land area be identified and allotted closer to the marble processing centres, for disposal of the pressed marble slurry cake. This land should be developed as a proper landfill site for which competent consultants should be engaged. It should be ensured that the marble slurry is disposed off only at the above earmarked site. To manage this site, a Trust be formed comprising of the representatives of Administration as well as the Industry. Sufficient land is earmarked around this landfill site for

allotment to entrepreneurs for Producing Building / Construction material based on marble slurry and these units may be developed in a cluster. The mine owners and processors must be bound to dispose the waste at such site that can be reused by various users of the waste in form of building material, filling material or ornamental bi products out of the waste irrespective of the dumping cost or disposal cost with implementation of rules under environmental protection rules. Regular maintenance of mine-machinery etc. stress on systematic development of mining pit for block mining. Introduction of pollution control measure at various levels (especially for dust and noise). Environmental control through regular monitoring and assessment with respect to changes was seen in surrounding land quality, workers health, surface and underground water, flora and fauna etc. Waste disposal and reclamation of waste land by afforesation. Roads of better quality for safe transportation of heavy marble blocks to reduce transportation waste.

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