RECYCLING POTENTIAL OF MARBLE INDUSTRY EFFLUENT

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It is to certify that the

Research and Development work titled

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Has been accepted towards the partial fulfillment

Of the requirements

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ABSTRACT

This study was conducted in Haider marble factory which was taken as case study for all marble processing units in Rashakai Industrial Estate. The main goal of study was to work on recycling potential of marble industry effluent and recommend recycling solution with cost analysis for utilization of marble waste products i.e Marble Slurry and Marble Wastewater. Analysis of waste marble slurry was done to identify its utilization in the construction industry in terms of concrete blocks. Different percentages (12%, 25%, 40%, 50%) of marble slurry were used as a replacement of sand content in production of concrete. Moreover, compressive strength test of marble concrete blocks was carried out after its necessary curing. Cost analysis of marble concrete blocks shows that depending upon compressive strength and percentage of marble content, an amount of Rs 15000/-, Rs 30000/-, Rs 50000/- and Rs 65000/- can be saved per month for 12%, 25%, 40%, 50% replacement of marble slurry respectively. At present, marble industry uses ground water as a coolant for marble processing. Marble processing unit produces wastewater with a flow rate of 39.6 cum/hr. This wastewater falls to Kabul River (through Kalpani Nullah) without any prior necessary filtration/recycling. This study also focuses on recycling aspect of marble wastewater with an aim of using recycled water as cooling water for marble processing. In this regard, it was proposed to design a re-sedimentation tank to refill OHWT and economize marble processing by reduction in the electricity consumption. Therefore, in recycling prospective of marble industry effluent, this study will be proved to be a reference and foundation stone.

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RECYCLING POTENTIAL OF MARBLE INDUSTRY EFFLUENT

CHAPTER-1

1.1 Introduction

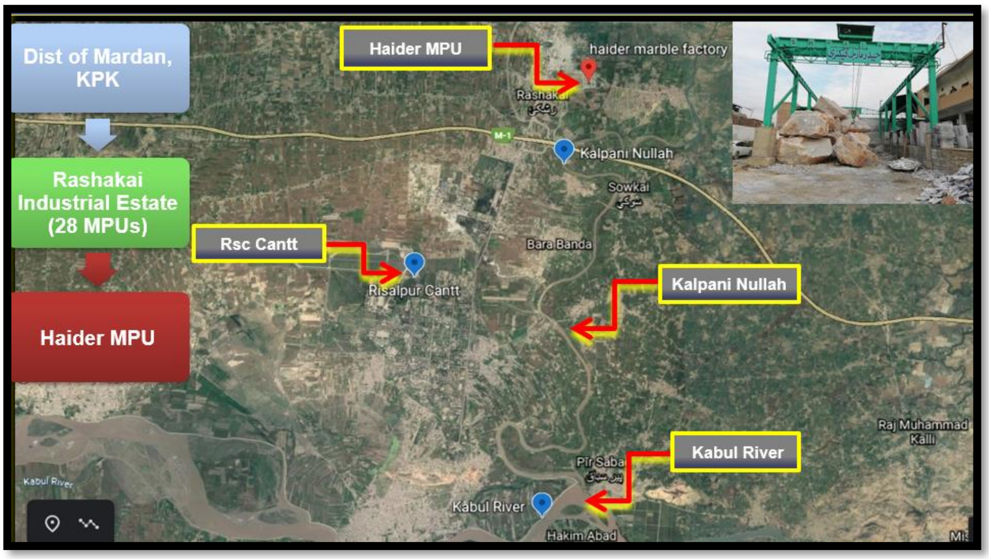
In various countries, industrial estates are established to fulfill the demand of growing population. The introduction of industries on one side manufactures useful products but at the same time generates waste products in the form of solid, liquid or gas that leads to the creation of pollution and numerous hazards. Wastewater from industries is discharged into the soil and water bodies thus poses a serious threat to human and functioning of ecosystem. In Pakistan, unfortunately industrial effluents are the main contributors to the surface and ground water pollution. Out of all industries, one of the major waste generating industry is the marble quarry and production industry. Marble is a form of metamorphic rock which is composed of recrystallized carbonate minerals (Kearey, 2001). Process of mining of marble involves blasting, drilling, quarrying, cutting and resizing of surface and subsurface deposits (Alzboon and Mahasneh, 2009). Marble processing unit generates large amount of wastewater and slurry during cutting and resizing phases of marble production. The purpose of this study was to know the process of marble slurry production and its utilization into valuable products.

1.2 Environmental Policy

Marble processing units (MPU ‘s) generate excessive amount of waste product in the form of marble slurry. This waste marble slurry can adversely influence the surface water quality of nearby water bodies after being discharged into it (Gokaltun, 2011). To deal with potential environmental threats, Pakistan introduced environmental protection ordinance in 1983. As per section 12 of the ordinance, Environmental Impact Assessment (EIA) was considered compulsory for all developmental processes and manufacturing expansions. Followed by environmental protection ordinance, National Environmental Quality Standards (NEQS) were formulated on 24th Aug 1993 for municipal and industrial effluents. In 2004, Pakistan Environmental Protection Agency developed Environmental Assessment Checklist (EAC), (attached at Annex A) with the aim to make environment friendly production. Environmental Assessment Checklist (EAC) comprised of 5 sections namely project description, screening, environmental profile around proposed marble factory’s site, impact assessment and undertaking duly signed from all stakeholders. Although Environmental Assessment Checklist was formulated in 2004 but unfortunately at present, neither the owners of marble industry had been adhering to the policy nor the Pakistan Environmental Protection agency is implementing it thoroughly. Moreover, marble waste products are being discharged into the environment without prior filtration and unfortunately recycling has not even been considered an option yet.

1.3 Area Under Study

The study is conducted in Distt Mardan, KP province of Pakistan. Rashakai marble industrial Estate is located at 8.6 kms North-East of Risalpur Cantonment. Industrial estate contains 28 marble processing units. This research focuses on parameters of one marble processing unit as a sample for all other marble processing units in the area. As a case study, Haider marble factory was selected which is located inside Rashakai marble industrial estate. The effluent of Rashakai marble industrial estate falls in Kalpani Nullah in the form of open drains and eventually it becomes part of Kabul River. Marble processing units produce large amount of marble slurry clustering the marble processing plants.



(**Figure 1.** General Area of Risalpur/Rashakai Marble Industrial Estate)

1.4 <u>Problem Statement</u>

Rapid development and growth in industrialization has adversely affect the ecosystem. Industrial activities are expanding to meet the growing demands of increasing population, ultimately leading to numerous issues like provision of safe drinking water, safe disposal of wastewater and production of solid wastes of industries. Marble effluent contains suspended impurities which can badly affect the aquatic fauna and can also be the main reason for contamination of water channels and drainage problems. Due to interaction of water with marble stone, suspended particles get dissolved and hence marble processing unit generates a waste product in the form of marble wastewater. Marble wastewater of Rashakai industrial estate flows to Kabul river through Kalpani Nullah without any necessary filtration or recycling. Unfortunately, this practice has made Kabul river as one of the waste dumping site. Apart from adversely impacting on aquatic ecosystem of surrounding area, marble wastewater is also affecting negatively on riparian rights of people living along the bank of river. Production of marble slurry is also a growing problem as it severely affects the ecology of areas clustering the marble processing factories. As marble slurry is dumped openly in the surroundings of marble processing units, it becomes a contributing factor for air pollution. The wet slurry dries up rapidly and inhaling the slurry particles cause a negative impact on the lungs and can cause respiratory problems (El Haggar, 2007; Vijayalakshmi et al., 2003).

1.5 <u>Objectives of the Project</u>

Following were the research objectives:

1. To study the process of marble slurry production.
2. To develop a plan for marble slurry utilization in construction industry.
3. To analyze and recommend utilization of marble wastewater.

CHAPTER-2

LITERATURE REVIEW

2.1 Harmful Effects of Marble Effluent

Many studies have been conducted to investigate harmful effects of marble waste on health risks but as relevant to the topic of this study, marble waste effects on water sources and air is discussed here.

2.1.1 Water Pollution

The water quality and aquatic fauna gets adversely affected by the disposal of untreated waste effluents into drains and ultimately to the rivers. Nafees, M. (2010) investigated on associated environmental problems of river Kabul. Industrial effluent from Mardan industries become a main contributor and throws untreated waste in river Kabul through Kalpani Nullah. In KPK, unfortunately Kabul River has become one of the waste dumping site. It has negative impacts on aquatic ecosystem and is also affecting the riparian rights of the people living along the bank in terms of drinking, bathing, fishing and washing.

Simsek & Karaca et al., (2005), researched on effects of uncontrolled marble waste disposal on water and sediment quality for the Fetrek river, Turkey. They conducted tests on 12 water samples from Fetrek river and ground water aquifer. They found that both the surface and subsurface water resources were influenced from uncontrolled disposal of marble wastes. The most noteworthy consequence was increased levels of various ions, found dissolved in water or solid in sediments. Particularly, the high quantities of $CaCO_{3,}$ high concentration of various an-ions, cations and turbidity in water pointed out that these waters were in violation of WHO standards. Finally they carried out pollution index analysis which verified that marble waste site acts as an anthropogenic source of toxic heavy metals.They calculated the pollution index using following formula.

Pollution Index (PI) = 1/6 x (Fe/5 + Cd/3 + Cu/100 + Mn/5000 + Pb/100 + Zn/300) where Fe, Cd, Cu, Mn, Pb and Zn are their levels in the sediment sample

Noreen & Uzma, et al. (2019), conducted study in Mardan Industrial Estate to analyse water pollution caused by marble industrial effluents and heavy metals bioaccumulation in the marble industry workers. Marble industrial effluent's sample analysis showed higher concentration of heavy metals i.e Cu, Mn, Zn and As in the marble industrial wastewater according to NEQs of WHO 2010. Higher concentration of heavy metals is hazardous for human health, agriculture crops, soil, ground water and aquatic life in the rivers and nearby streams.

2.1.2 Air Pollution

Processing of marble results in the formation of marble dust, which suspends in the air. The marble workers are occupationally exposed to intense marble environmental marble dust in their workplace and it is inhaled by the workers. Individuals who work at marble work sites from the process of quarrying, grinding, polishing and installing marble are widely exposed to marble dust (containing particles of calcium carbonate and silica). The prolonged exposure to respirable crystalline silica is famous to cause one of the oldest industrial disease, silicosis (Pilkington et al., 1996; Tjoe-Nij et al., 2003). Epidemiological studies indicate that workers exposed to marble dust stand an increased risk of suffering from asthma symptoms, chronic bronchitis, nasal inflammation and impairment of lung function (Camici et al., 1978 Angotzi et al., 2005; Leikin et al., 2009).

2.2 Usage of Marble Slurry in Construction Industry

2.2.1 Characteristics of Marble Slurry

Shah, W. (2016). worked on life cycle assessment of marble slurry and waste products. In his research, he did marble slurry sampling by collecting marble slurry from 20 different marble processing units, taking 5 representative samples from each. Marble slurry powder collected from different settling tanks contained 19.4% moisture content. In order to check the suitability of marble dust as filler material, fineness of marble slurry powder was determined by sieving according to ASTM C117. Results showed that 85% of marble slurry particles passed through 75 µm sieve and only 15% were retained. Therefore, using marble slurry in useful products in its original fineness is viable option instead of further grinding the dust particles. It was also observed that marble slurry attains quick dryness in air as it has a low water absorption value (0.43). Moreover, marble slurry has specific gravity of 2.7 and average density of 1.4 g/cm^3.

During the physical treatment process, Shah, W. (2016). treated marble slurry samples with detention time and no chemicals were added. Although, Domopoulou, Asimina E., et al. (2015) recommends use of ferric chloride as coagulant to speed up the process of marble slurry settlement. Shah, W. (2016). observed the sedimentation for 24 hours and founded that 90% of suspended load gets settled in 1-hour time. They used graduated glass cylinder of 1000 ml and 2.5inch diameter to determine the settling velocity of marble dust particles. Time was noted by stopwatch and it was observed that suspended particles are slightly heavier than water and settles slowly with the velocity of 3-5 m/hr.

2.2.2 Use of Marble Slurry in Concrete

For achievement of sustainable development, usage of marble waste as a material can be helpful as an environmental management tool. Improper handling and disposal of recycle material can become an environmental hazard if treatment is not based on scientific research and development. Marble waste generated during quarrying operation can be unsafe and harmful for the environment. In this modern age, the cost of construction material is increasing day by day. The effect can be reduced by utilization of marble waste material in the production of concrete. Processes like marble cutting, polishing and grinding generates tons of waste material as a slurry. Direct exposure of these waste material to the environment can cause adverse environmental hazards.

Bacarji et al. (2013), researched about the utilization of marble and granite stone in concrete. Marble and granite stone processing wastes were collected and laboratory analysis showed that the marble and granite stone processing waste did not contain any hazardous and reactive materials and thus can be used as fillers.

2.3 Marble Wastewater Treatment

The process of marble saleable products involves cutting, grinding and polishing the raw ore into marble sheets of defined shapes and sizes. Water is an essential ingredient aiming at cooling down the gang saw / bridge cutters and in removing fine dust particles. Domopoulou, Asimina E., et al. (2015) worked on marble wastewater treatment in the region of western Macedonia, Greece. After studying mineralogical composition of marbles, they collected samples from two different marble processing plants. A jar-test was carried out for the coagulation/flocculation experiment which showed that hydrated ferric tri-chloride and aluminium sulfate proved to be efficient coagulation/flocculation reagents for treating marble wastewater. Study revealed that the sedimentation time of 25 minutes can be achieved by using ferric tri-chloride as coagulant. More detention time can render easy settlement of thick slurry in the sedimentation tanks.

Shah, W. (2016). researched that specific gravity of marble slurry is which is greater than that of water. They concluded that sedimentation is carried out to get rid of those suspended particles which have high specific gravity than water and so can easily be settled. They observed settlement of marble dust particles in water and concluded that 90% of marble sludge gets settled within a settlement time of 1 hour.

CHAPTER - 3

METHODOLGY

3.1 Marble Slurry Production Process

Marble is a processed material made from large heavy marble blocks after its cutting, polishing and resizing. The process of cutting and resizing of large heavy stones into useable marble pieces consumes extensive water. This water (after processing) converts into marble effluent which settles in the form of thick marble slurry and becomes a main source of contamination for environment surrounding the marble factory. Marble production starts by extraction of large heavy marble blocks from the quarry site by conventional blasting methods using explosives. The cut blocks usually 50-60 tonnes in weight are then stored in a yard from quarry site by means of cranes. The processing of marble stone is divided in cutting and polishing stages in the processing units which generate marble effluent.

(**Figure 2.** Collection of Marble Blocks at Factory Yard)

3.1.1 Bridge Cutter and Cross Cutter Machine

Preliminary cutting of large heavy stones into smaller useable stone blocks is done using bridge cutter machine. Process involves extensive groundwater usage as irregular blocks are converted into regular blocks by application of mono blade cross cutters.

(**Figure 3 & 4**. Bridge Cutter Machine and Cross Cutter Machine)

3.1.2 Gang Saw Vertical Belt Unit

Rectangular blocks are then moved to gang saw belt unit (with vertical cutter) for further cutting into smaller and more workable marble sheets. Gang saw belt unit uses maximum amount of water, which is primarily used to cut a 2 inches square slab piece into further 3 thinner square marble sheets of 0.6 inches each.

(**Figure 5.** Gang Saw Vertical Belt Unit)

3.1.3 Resizing and Polishing Machine

Marble sheets are moved to the resizing machine for cutting into desired sizes and finally to the conveyer line for the polishing, where they are laid horizontally on a large conveyer type line called a polishing line.

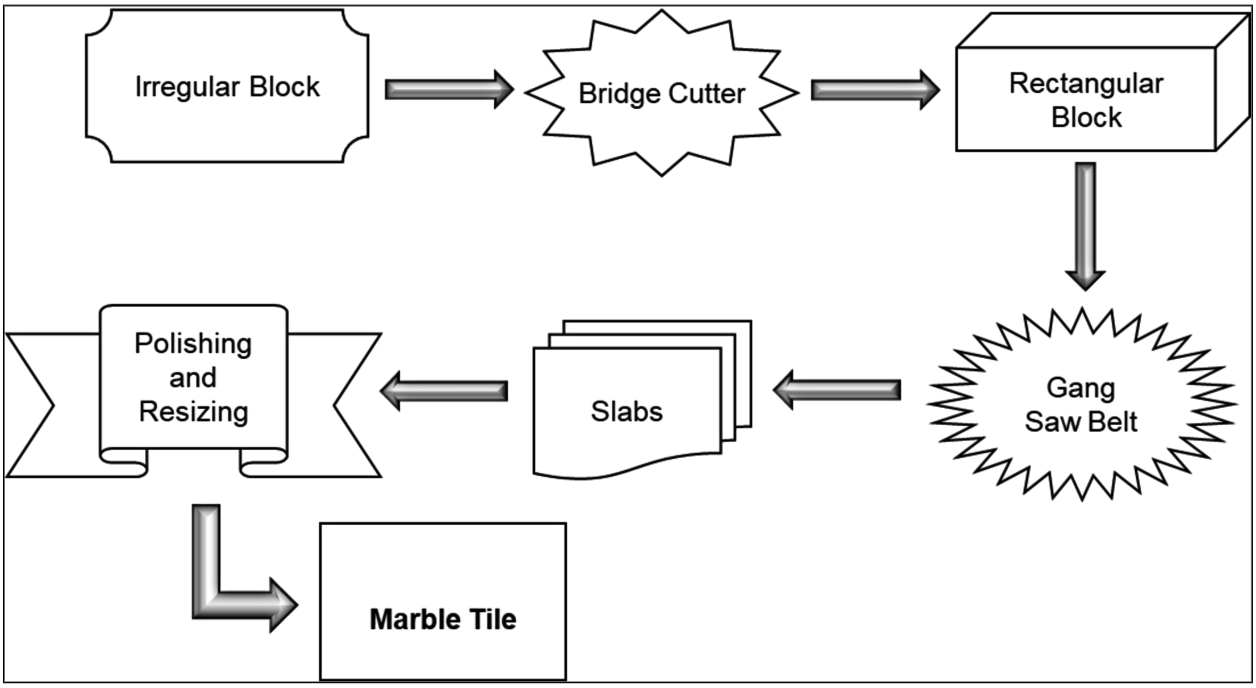

(**Figure 6 & 7**. Resizing & Polishing Machine)

3.1.4 Sedimentation of Marble Slurry

Water is an essential ingredient used in all phases of marble production. Groundwater is used in marble production process which is pumped out with the help of water pumps and after contact with marble surfaces, it turns into white thick liquid called marble wastewater. Marble wastewater is collected in sedimentation tanks with the help of small open drains. When collected in sedimentation tanks, wastewater forms marble slurry (a thick white powdered material). Each sedimentation tank has a dimension of 10 x 7 x 10 (ft). Depth of sedimentation tank is 10 ft, which gets enough accumulation of slurry that it needs to be emptied regularly on weekly basis. Slurry and marble wastewater are the two waste products of marble factory.

(**Figure 8.** Sedimentation Tanks)

3.1.5 Manufacturing Process



(**Figure 9**. Manufacturing Process of Marble Producing Unit)

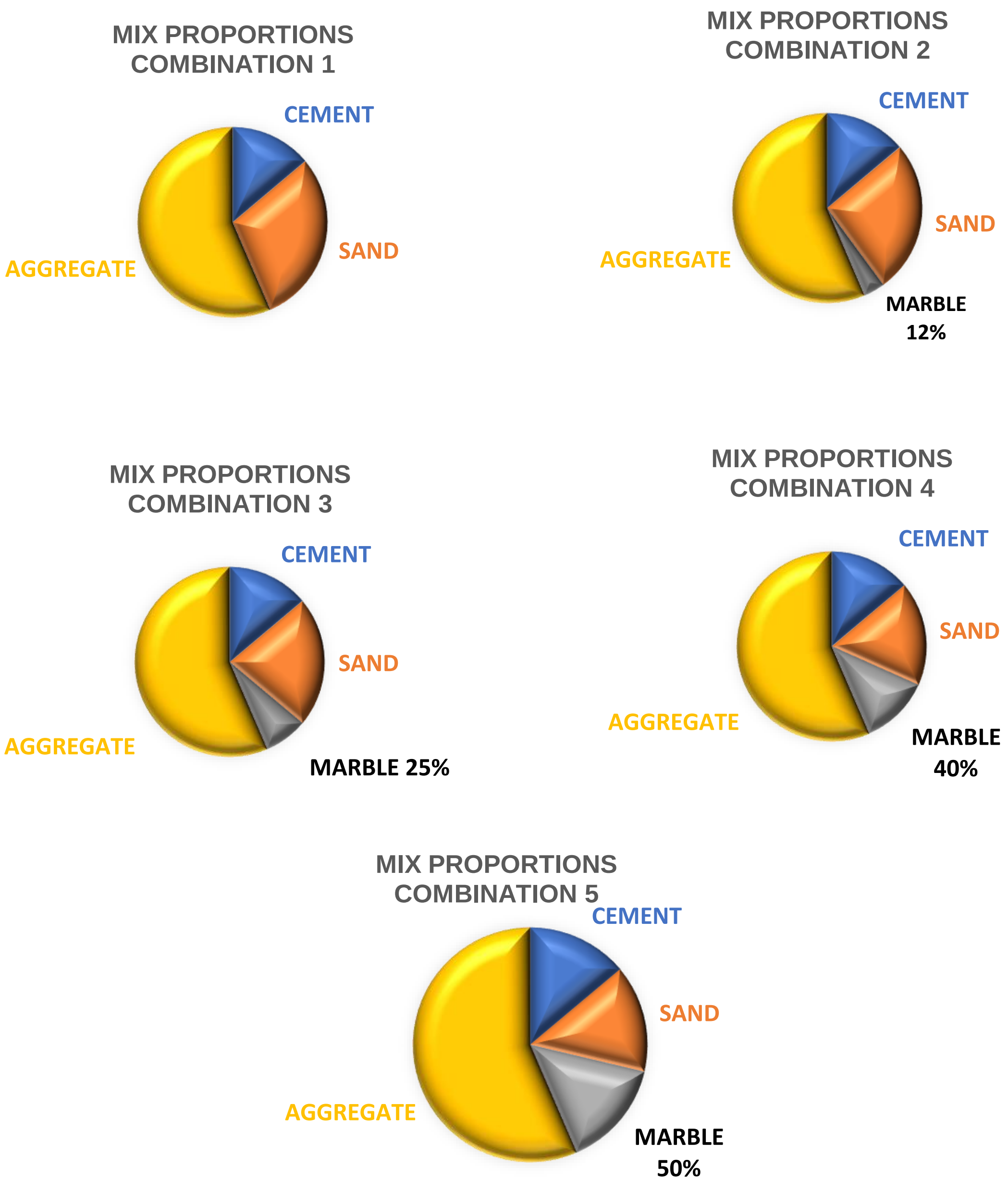
3.2 Marble Slurry Utilization

Marble slurry can be utilized in many ways in construction industry. Studies have been conducted to use marble slurry as a structural fill material in road embankments, in preparation of bricks (replacing lime), as a raw material for manufacturing of ceramic tiles and for preparation of hollow prefabricated blocks for buildings. In this research, different proportions of marble slurry were utilized for preparation of concrete blocks. Concrete blocks were prepared at Rashakai block factory in which marble slurry was utilized by reducing sand content. Four different ratios of sand and slurry along with cement and aggregate were used to prepare concrete blocks (12”x7”x6”). Sand proportions were replaced with marble slurry at rate of 12%, 25%, 40% and 50%(by weight). Necessary curing process was completed for 28 days. The compressive strength test was conducted after 7 days but unfortunately 28 days strength test couldn’t be conducted due to onset of corona epidemic.

3.2.1 Concrete Mix Proportion. Mix Material by Weight (kg)

Marble Concrete for 6 Blocks Manufacturing					
Combinations	**Marble %**	**Cement (kg)**	**Sand (kg)**	**Marble Slurry (kg)**	**Aggregate (kg)**
1	0	15	32	0	61
2	12	15	28.15	3.85	61
3	25	15	24	8	61
4	40	15	19.2	12.8	61
5	50	15	16	16	61

(**Table 1.** Concrete Mix Proportion)



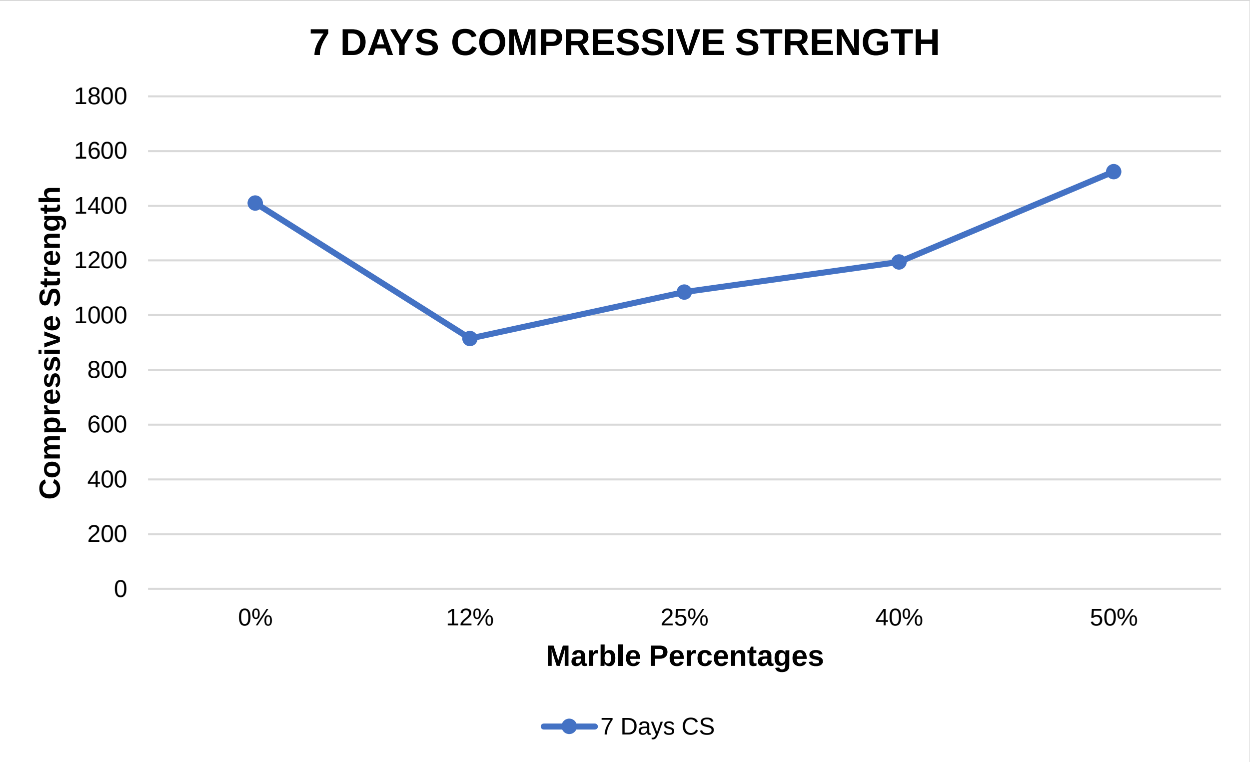
(**Figure 10.** Graphical Representation of Mix Proportion Combinations)

3.2.2 Compressive Strength of Marble Concrete

Following are the Compressive Strength of Marble concrete blocks with varying percentages of marble waste

Marble %	Compressive Strength	
	7 days (75% hydration)	28 days (95% hydration)
0	(1510 + 1308 + 1414) = 1410 psi	
12	(769+1080+896) = 915 psi	
25	(1096+954+1204) = 1085 psi	
40	(1205+986+1165) = 1195 psi	
50	(1751+1359+1465) =1525 psi	

(**Table 2.** Compressive Strength of Marble Concrete)



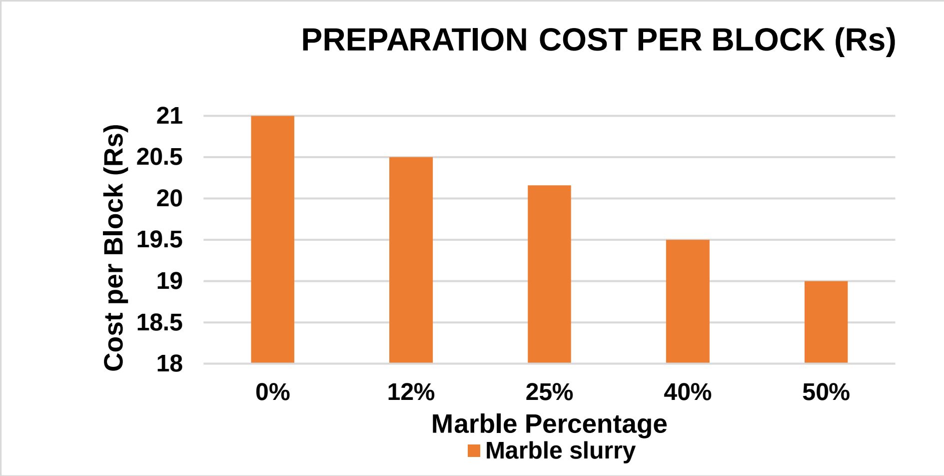
(**Figure 11.** 7 Days Compressive Strength)

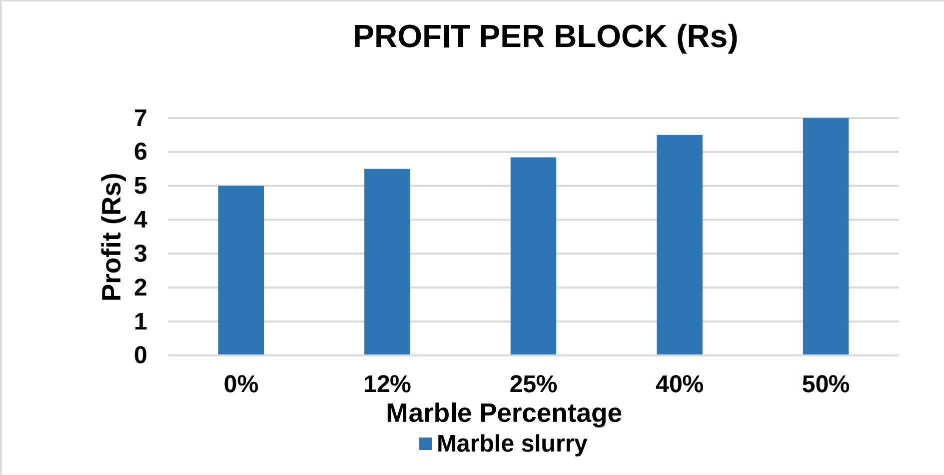
3.2.3 Cost Analysis of Marble and Concrete Block

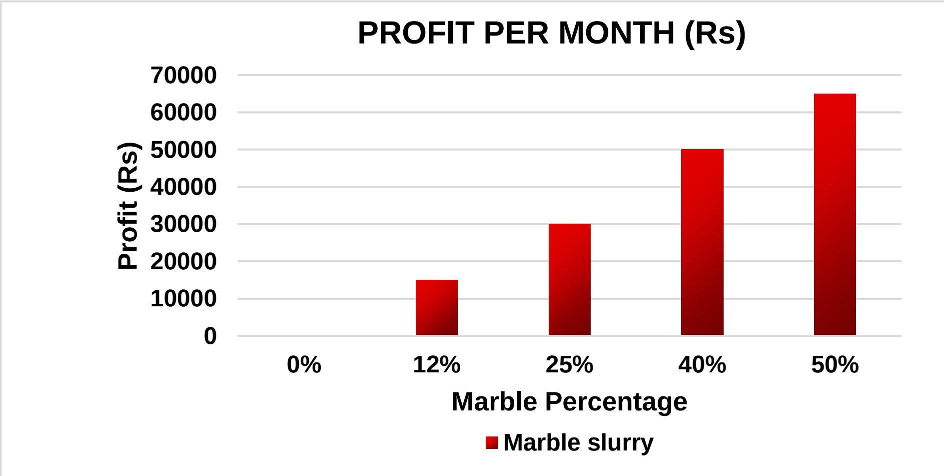
6 x Blocks Preparation										
	Marble 0%		Marble 12%		Marble 25%		Marble 40%		Marble 50%	
	Qty (kg)	Rate (Rs)	Qty (kg)	Rate (Rs)	Qty (kg)	Rate (Rs)	Qty (kg)	Rate (Rs)	Qty (kg)	Rate (Rs)
Sand	32	25	28.16	22	24	18.75	19.2	15	16	12.5
Cement	6	60	6	60	6	60	6	60	6	60
Aggregate	17	42	17	42	17	42	17	42	17	42
TOTAL (Rs)	**-**	**127**	**124**		**121**		**117**		**114**	
At avg Block/day Cost (Rs)	1200	25400	24800		24200		23400		22800	
Prep cost per bock		21	20.5		20.16		19.5		19	
Profit per day (Rs)	1200	-	600		1200		2000		2600	
Profit per month (Rs)	30000	-	15000		30000		50000		65000	
Factory selling price (Rs) per block	**26**									
Profit per Block (Rs)		**5**	**5.5**		**5.84**		**6.5**		**7**	

(**Table 3.** Cost Analysis of Marble Concrete Blocks)

GRAPHICAL REPRESENTATION OF COST ANALYSIS







(**Figure 12.** Graphical Representation of Cost Analysis)

3.3 Utilization of Marble Wastewater

Water is an essential element of marble industry and serves as lifeline to this industry. Procedures like cutting, sawing and polishing requires plenty of water to produce a well graded finish product. Availability of such an essential entity depends on location of production unit and bylaws of respective industrial estates. The production unit under study (i.e. Haider Marble Factory) uses groundwater for marble production. Currently, water is being stored in the overhead water tanks (OHWT) storage with the help of 2 x 10 hp water pumps. An OHWT of 1152 ft^3 (12'x12'x8') capacity is being used for storage and gets refilled 8 times a day to fulfill the requirement of the production unit. Factory uses 9216 ft^3 water per day for production of finished marble products. After interaction of water with marble, suspended solids gets dissolved and it flows in the form of industrial waste. This industrial waste from the marble industry carries marble slurry and different type of other impurities. It was observed that 8390 ft^3 of industrial waste contains 415 ft^3 (5%) marble slurry and 7634 ft^3 (95%) of wastewater per day which flows out from the open drain. In this section, recycle plan of 7634 ft^3 marble wastewater will be discussed.

3.3.1 Chemical Properties of Marble Wastewater

Chemical examination report of wastewater as done in PHE laboratory shows that marble wastewater has higher concentrations of TSS and TDS. Resultantly, sedimentation of marble slurry is imperative to get a decreased TSS and TDS values. Chemical analysis report of marble wastewater is attached as per Annexure B.

3.3.2 Design of Re-Sedimentation Tank

Based on the discharge of wastewater and its chemical examination, purification tanks are suggested, dimension and parameters of which are shown below.

Velocity = 0.2 ft/s

Area of drain = 2 ft^2 = 0.1858 m^2

Q= AV = 0.011 m^3/sec = 39.6 m^3/hr

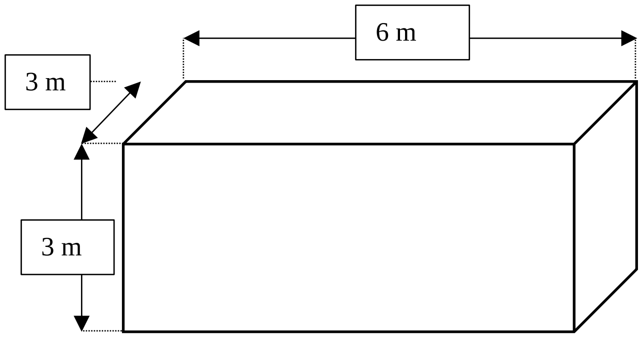
Let

Surface Loading Rate (SLR) = 2.2 m^3/m^2/hr (SLR Range 2 - 5.6 m^3/m^2/hr)

Area = 39.6/2.2 = 18 m^2

Let it be a Rectangular Sedimentation Tank

So, Length = 6 m, Width = 3 m, Depth = 3 m



(**Figure 13.** Design of Re sedimentation Tank)

3.3.3 <u>Recycle Plan</u>

Conservation of water is a matter of great concern around the globe. Industries all around the world are trying to reuse the energy and reduce production costs. Contrary to practices being followed in world, industries in Pakistan are not focusing on recycling and re-utilization of waste products. Unfortunately, marble industry of Rashakai Industrial estate is also not focusing on recycling of wastewater and reusing of waste material (i.e marble slurry). Recycle plan is aimed at optimization of marble processing by recycling of wastewater and slurry. It will have a direct bearing on reduction of electricity consumption cost. Slurry gets accumulated in the resedimentation tank. Based on nature of settlement of slurry, a detention time of 2 hours is sufficiently enough after which slurry gets settled and wastewater can be used for secondary useful purposes. Though, reuse of marble wastewater for different purposes largely depends upon the level of filtration. This study focuses on reuse of marble wastewater for cutting of marble raw stones. Presently, 2 x motor pumps (2 x 10 hp) are being used at Haider Marble factory. Recycled water from re-sedimentation tank will be pumped up to overhead water tank using 5 hp motor and it will take 38 minutes to refill OHWT.

Height of OHWT from Re sedimentation tank (Head) = 21 m = 70 ft

Weight of 1 litre of water = 2.2046 lbs

As, 1 hp = 550 ft.lb/sec = 33000 ft.lb/min

Using 5 hp of motor

i.e 5 hp = 165000 ft. lb/min

Therefore, 165000/2.2046 = 74843 ft.lit/min

Assuming pump efficiency as 80%

74843 x 0.8 = 59874 ft.lit/min

So, Flow rate for 70 ft head = 59874/70 = 855 lit/min

As, Capacity of OHWT (12 x 12 x 8) ft = 1152 ft^3 = 32.6 m^3 = 32615 lit

So, Time to fill OHWT using 5 hp = 32615 / 855 = 38 mins

Result: It will take 38 mins for 5 hp motor to fill OHWT of 32615 lit.

3.3.4 Cost Analysis Using Recycle Water

Cost analysis aims at calculations of electricity consumption for existing installed motor pumps at Haider marble factory. At present, 2 x 10 hp motor pumps are installed to pump water from underground (depth 200 + 70) ft which costs Rs 30,200 /- of electric bill / month. Suggested plan (discussed below) aims at usage of 1x 5 hp motor and 1 x 10 hp water pumps which uses filtered water from re sedimentation tanks to fill OHWT (height 70 ft). Comparison of existing electric consumption with suggested plan depicts saving of Rs 7584/- per month.

3.3.4.1 Existing Electricity Consumption at Haider Marble Factory

2 x 10 hp submersible motor pumps are already installed to uplift water at height of 270 ft.

10 x 746 = 7460 watts = 7.46 KW

Assuming 80 % as pump efficiency

7.46 x 0.8 = 5.968 KW

Units consumed = Power x No of hrs of operation

= 5.968 x 4

= 23.872 units / day

For 25 days = 23.872 x 25 = 597 units/month

Rate of Electricity (for Peak hours)

1 unit = 18.88 Rs / commercial units (+ 17% GST, + 5% Fuel cost surcharge, + 12% income tax)

Cost Per Month for 10 HP Motor Pump

18.88 x 597 = Rs 11271/-

Cost Per Month for 2 x 10 HP Motor Pump

2 x 11271 = Rs 22543/-

GST (17%) = Rs 3831/-

Fuel cost surcharge (5%) = Rs 1127/-

Income tax (12%) = Rs 2704/-

Total existing monthly bill = 22543 + 3831 + 1127 + 2704 =Rs 30,200/-

3.3.4.2 Suggested Plan – Electricity Consumption

Re sedimentation tank (6 x 3 x 3) m is suggested with 1 x 5 hp water pumps for pumping of recycled water to OHWT (height 70 ft). Calculations is as follows:

5 x 746 = 3730 watts = 3.73 KW

Assuming 80% as pump efficiency

3.73 x 0.8 = 2.984 KW

Units consumed = Power x No of hrs of operation

= 2.984 x 4 = 11.936 units/ day

For 25 days = 11.936 x 25 = 298.4 units / month

Using 18.88 Rs/- rate with 17% GST, 5% Fuel cost surcharge, 12% income tax

Cost of electricity bill for 1 x 5 hp motor pump = 5610 + 954 +280 + 673 = Rs 7516/-

However, **use of 1 x 10 hp and 1 x 5 hp is suggested**

Electricity cost of 1 x 10 hp and 1 x 5 hp

1 x 5 hp = Rs 7516/-

1 x 10 hp = Rs 15100/-

Total = Rs 22,616/-

Consumption difference per month = 30200 – 22616 = Rs 7584/-

Hence, by using 1 x 10 hp and 1 x 5 hp water pumps after recycling of water, we can save electric cost of **Rs 7584 /-** per month.

CHAPTER - 4

EXPECTED OUTCOMES AND DISCUSSION

Marble enjoys a significant status in the construction industry. It is extensively used in the ornamental works, interior finishes, flooring and crockery etc. Raw marble undergoes through an extensive and systematic processing before being transformed for these purposes. Such large-scale usage demands a considerable industrial production and processing, which resultantly produces heavy amount of pollutants in air, water and soil. Keeping in view the significance of this industry and its drastic effect on environment it was chosen as a case study.

4.1 **Adherence to EPA Protocols.** During our course of research, we learned the detailed process of marble refinement. The processing of marble produces a large quantity of slurry and harmful air particles. It was expected that the processing plants and other manufacturing units in the Rashakai Industrial zone would be following the SOPs and guidelines issued by EPA of KP but the situation on ground was telling some other story. Marble processing units in the Rashakai Industrial Zone were not following such SOPs and protocols issued by EPA of KP. Labour in the processing units were completely unaware of the such protocols and SOPs. No safety equipment was given to the labour working in the marble factories. As marble waste composed of air particles and slurry, the air particles at site of cutting and processing within the premises of marble factory were causing serious breathing problems for the workers and the people in the vicinity. The slurry produced in the processing and polishing of the marble were only being accumulated in the sedimentation tanks which eventually got emptied after 5-7 days depending on the production and whole waste material either dumped in open or being disposed into the Kabul River without any further filtration and treatment. This maltreatment with such dangerous industrial waste has a devastating effect on the aquatic life of Kabul river as well as and the sediments all along the water course which effects the soil and vegetation. High values of marble waste in freshwater streams and rivers causes different kind of health hazards to the humans living in the vicinity of the industrial area.

4.2 **Usage of Marble Slurry.** Marble waste material use is a very vital management tool for attainment of sustainable ecofriendly environment growth. Contrary to this, recycle of waste without proper and justified scientific research and development can result in environmental hazards bigger than the waste itself. Marble cutting, processing and polishing operations result into heavy amount of marble waste which can be unsafe and a danger to ecosystem. To address this issue during our course of research it was thought to take some benefit out of such hazardous material. One such thing was usage of marble waste in the construction industry in production of low-cost concrete. This would not only reduce heavy material cost but would also helps us to make environment clean. To make this idea practical, building blocks were casted while using the marble slurry as the replacement of the sand proportion. It was expected that there will be a little or no change in the properties of the building blocks on the introduction of marble slurry in the concrete mixture especially on one of the most concerned property i.e Compressive strength of the building block. The results obtained after casting, curing and testing of the concrete building blocks were different from the expectations. Initially, on replacement of sand proportion with marble slurry, the compressive strength of the concrete building blocks decreased but as the proportion of the waste marble powder increased, the strength showed an increasing trend. This shows that the marble powder possesses cementing properties and enhancing cohesiveness due to lower fineness modulus of the marble powder. Furthermore, the mean strength of concrete mixes with marble powder was 5-10% higher than the reference concrete with 0% marble slurry i.e. 1410 psi. The slight decrease in compressive strength values of concrete were noted when 12% by weight of marble powder was used as compared with that of 25% and 50% by weight marble powder mix.

4.3 **Wastewater Recycling.** Water is one of the most important substance on the Earth. Every activity on earth somehow revolves around the usage of water. That's why water is needed to survive, if there was no water there would be no life on earth. With the increasing population, the demand of water has also increased with time not only in terms of consumption for domestic and agricultural purposes but also at industrial level which has caused a great burden on the present water resources. This demands for advanced techniques in utilization of water for the conservation of resources. Marble industry is one of the major consumers of water in industrial sector. In fact, it is the backbone of this industry. Not a single operation in the marble industry can be performed without availability of excessive water. It was expected that marble industry would have been taking measures to conserve water for their usage instead of only relying on groundwater. In our area of study, unfortunately no such measures were being taken to conserve or optimize the use of water. The marble unit which was selected for the case study uses water from groundwater source. Water being pumped up with the help of 2 x 10 HP motors into the OHWTs. This process continue for whole day at least 6-8 times a day depending on the demand. Thousand of liters of water have been utilized to produce marble and create slurry as a waste material which is running in open drain without any treatment and conservation. Lack of knowledge in the marble factory owners will have far drastic consequences on the water resource of the area. Such large consumption of water will not only lower the ground water table in and around the industrial estate but also affect negatively on riparian rights of people.

Serial No	**Expected Outcome Summary**		
	Characteristics	**Expected**	**Outcome**
1	Adherence to EPA Protocols	Yes	No
2	Usage of Marble Slurry	Usage in secondary Products	Not being used
3	Wastewater Recycling	Recycling at site	No recycling of wastewater
4	Strength of Marble Concrete Blocks	Higher than Concrete Blocks	Not much marked difference

(**Table 4**. Cost Analysis of Marble Concrete Blocks)

CHAPTER 5

ANALYSIS AND RECOMMENDATIONS

5.1 Analysis

Marble slurry and wastewater are two waste products that can be reused/recycled into useful purposes. This research focuses on usage of marble slurry as a filler material in preparation of low-cost concrete blocks. Marble processing unit produces 16 tons of marble slurry per day. It is due lack of awareness that so far marble slurry has not been used in preparation of secondary useful products and tons of slurry becomes waste and play an active role in air pollution. Importance of recycling not only helps in mitigation of environmental pollution, but it can also help in preparation of secondary products at low-cost. In marble industry, recycling perspective is not only limited to marble slurry alone as marble wastewater can also be recycled and play a pivotal role in economization of marble processing.

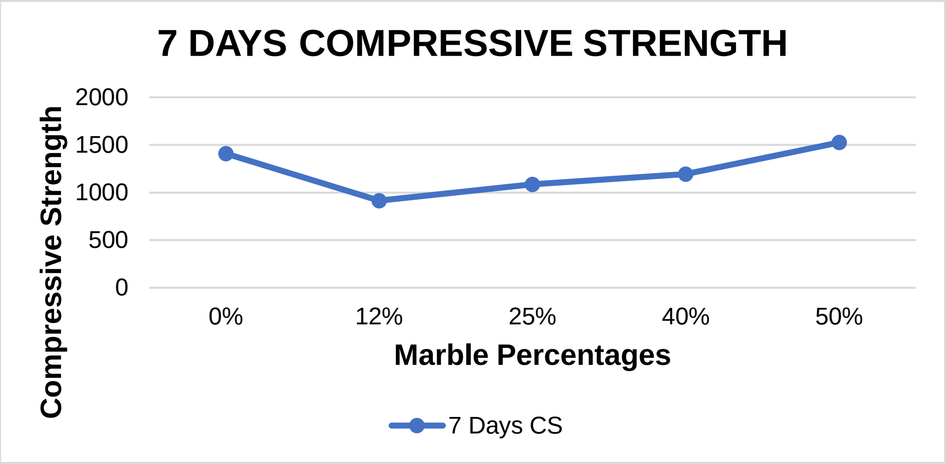
5.1.1 Utilization of Marble Slurry

Marble being a major industry in construction and ornamental works produces extensive waste in terms of slurry and wastewater which gets dumped outside marble factories. According to study conducted by Shah, W. (2016), a marble processing unit (having dressing, cutting and polishing processes) at an average produces 15 tonnes /day of powdered waste in the form of marble slurry. It is due lack of awareness regarding such a useful byproduct that it is dumped in open around the periphery of marble processing units thus it not only becomes surplus waste material but also pose a serious health hazard in the form of air pollution. Moreover, results of sieving analysis also showed that 85% of marble slurry particles passed through 75 μm sieve and only 15% were retained, thus marble slurry can be used a filler material in its original form. Research and study of earlier works revealed that marble slurry had been used for different purposes like preparation of dish washing powder, as ingredient of cement, experimented to be used in construction industry as low cost concrete (with 5%, 10% and 15% replacement of sand).

In present era, desire of owning a house has increased the importance of construction industry manifolds. For this purpose, different methods are adopted, and different materials are used to economize the process of construction. One of such endeavor is to use concrete blocks in construction industry as they have a larger size as compared to standard bricks and are also easily available on cheap rates. This research paper focuses on use of marble slurry in construction industry as a replacement of sand in concrete blocks. Major ingredients for construction of concrete block includes cement (binding material), sand (filler) and aggregate (strengthening material). Cost of concrete block can further be reduced if a portion of filler material (sand) is replaced with marble slurry. It is pertinent to mention here that 100% of sand cannot be replaced by marble slurry as marble slurry is dissolvable in water thus will give minimal strength to concrete block. An effort in this regard was done by using 12%, 25%, 40% and 50% marble slurry as a filler material replacing proportion of sand in a mix.

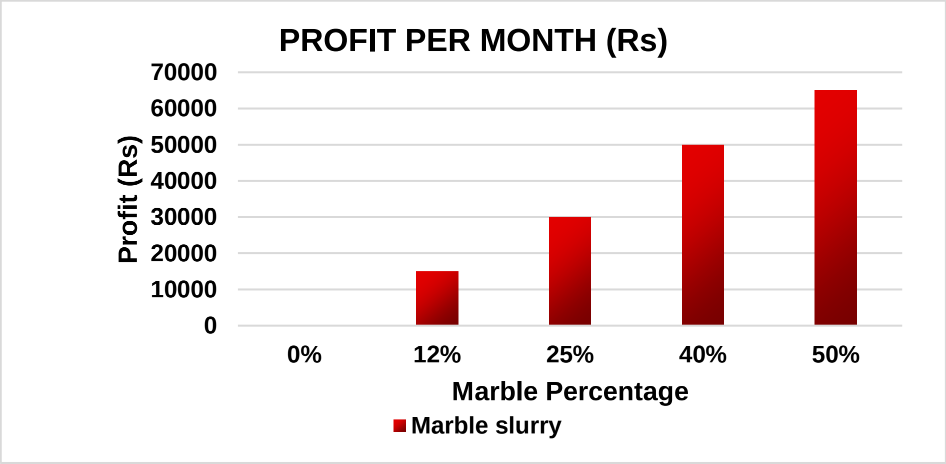
5.1.1.1 Results

- **Compressive Strength:** 7 days compressive strength test was conducted for the marble concrete blocks which depicted the highest value for 50% marble slurry replacement block. Unfortunately, due to outspread of Corona virus and closure of PRC lab, 28 days compressive strength test was not be conducted.



(**Figure 14.** 7 Days Compressive Strength Result)

- **Cost Analysis of Marble Concrete Blocks:** Marble concrete blocks were casted from Rashakai block factory which produces 1200 blocks per day. Different mix proportions were prepared on site and 6 x blocks of each percentage (i.e 12%, 25%, 40% and 50%) were casted. For casting 1200 blocks (average) per day, if manufacturer ignores use of marble slurry, it will cost 25,400 Rs/- manufacturing cost. Use of marble slurry as replacement of sand considerably reduces manufacturing cost @ Rs 24,800 for 12%,Rs 24,200 for 25%, Rs 23,400 for 40% and Rs 22800 for 50% respectively. As marble slurry is dumped as a waste product outside marble processing units, it can be procured and heaped in block factory without paying any procuring charges. Based on the percentage of marble slurry replacement in sand, a block factory owner can monthly save Rs 15,000, Rs 30,000, Rs 50,000 and Rs 65,000 for 12%, 25%, 40% and 50% respectively.



(**Figure 15.** Cost analysis per month)

5.1.2 Recycling of Marble Wastewater

Marble cutting and processing being a comprehensive process uses excessive quantity of water and produces large amount of wastewater. Now a days, almost every marble processing unit is using wet cutting technology in which cooling water is used as a wet cutting and sawing of marble stones with an aim to reduce the heat produced by friction between saw blades and marble stones. Cooling water is obtained from ground water source and is pumped up using different water pumps. Wet cutting technology uses considerable amount of water for marble processing which results in equal production of huge amount of wastewater. Flow rate of wastewater calculated at Haider marble factory was 39.6 m^3/hr. As per instructions of EPA, it was mandatory for every marble factory to perform necessary water filtration before disposal of wastewater as it causes adverse effects for aquatic fauna and pose various environmental hazards but unfortunately this practice is not being followed in true letter and spirit.

5.1.2.1 Existing Wastewater Disposal System: Under. Pakistan Environmental Regulation-2004, construction of sedimentation tanks was made obligatory to mitigate the harmful effects of marble wastewater. In this regard, 3 sedimentation tanks were constructed, and wastewater was made to flow through these sedimentation tanks with considerable amount of slurry settled at the bottom. It is important to mention here that presently Haider marble factory uses 2 x 10 hp water pumps to pump groundwater (depth 270') to OHWT (12' x 12' x 8'). This water is used as coolant for all cutters. It is also to be noticed that marble production is an expensive process as it involves massive consumption of electricity. To pump ground water to OHWT, 2 x 10 hp consumes 597 units/month making an electric bill of 30,200 Rs/- per month.

(**Figure 16.** Existing Sedimentation Tanks)

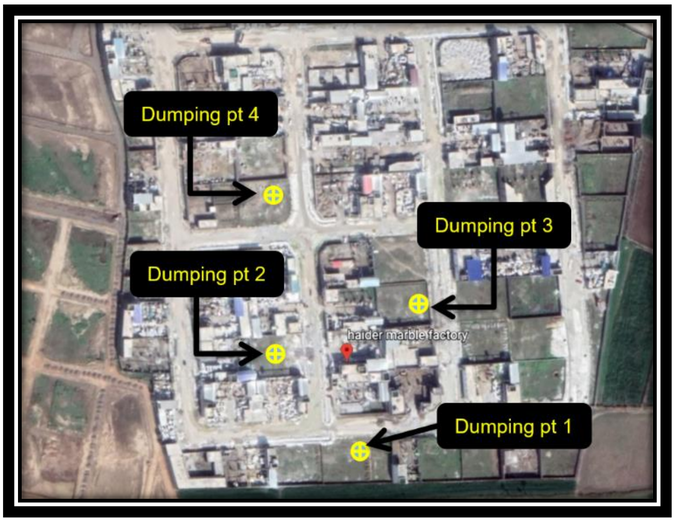
5.2 Recommendations

Marble is used extensively in construction industry for its beauty in architecture and sculpture. Very few rocks hold as many uses as marble. Though marble industry has achieved marked significance in construction industry but unfortunately due to lack of awareness, recycling/ resuse of marble waste products has been ignored. Same is the case with Rashakai industrial estate, where marble slurry is dumped all around the perimeter of marble processing units and wastewater is being discharged to Kabul river through Kalpani Nullah. This not only results in underutilization of valuable waste products but also spreads serious environmental hazards in the form of air and water pollution. Following is recommended in this regard:

5.2.1 Marble Slurry Dumping Points. It is recommended that marble factories should be insisted by Environmental Protection Agency to dump marble slurry at centrally selected marble slurry dumping points. As slurry has low water absorption value, therefore it dries quickly. Dumping marble slurry around the periphery of industrial units not only results in increase of air pollution but will also make it difficult for concrete block factory owners to collect it for its utilization in preparation of concrete blocks as a replacement. Rashakai industrial estate contains 28 marble factories and 4 dumping points are recommended for proper disposal of marble slurry. Size of each dumping point should be (15 x 15 x 6) m. Establishing dumping points will give two major benefits:

- Firstly, it will result in considerable reduction of air pollution as they are covered from three directions.
- Secondly, it will decrease the quantum of effort involved in collection of marble slurry if it is to be used in preparing secondary beneficial products.

Proposed locations of dumping points are as under:



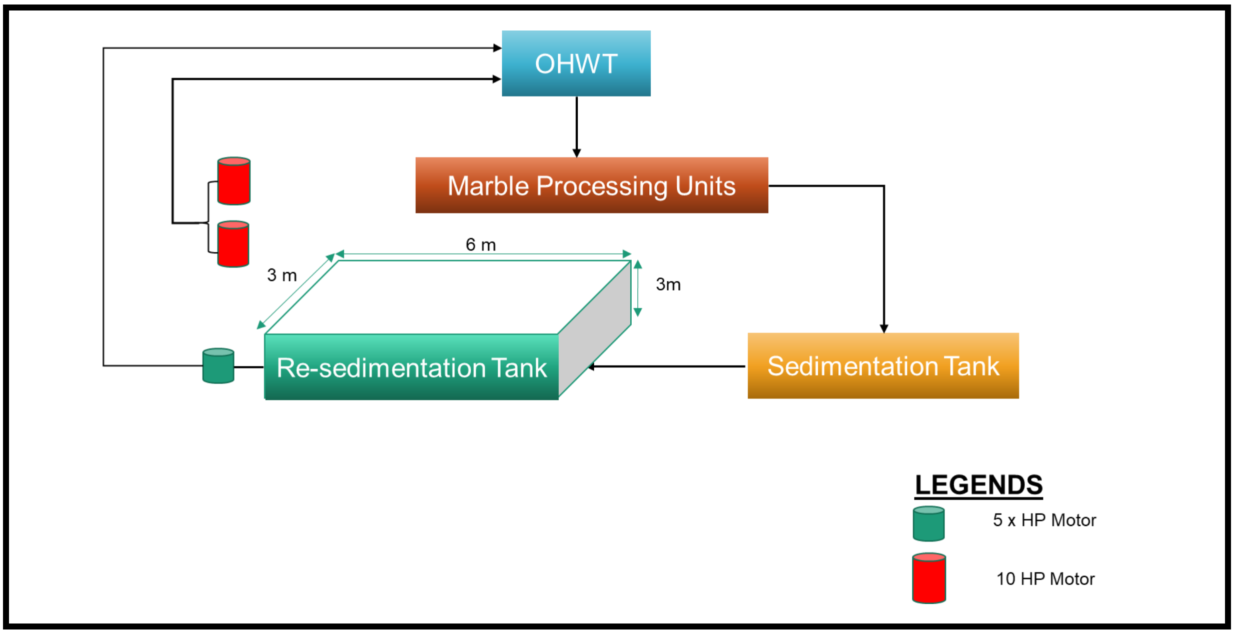
(**Figure 17**. Recommended Dumping Points locations)

5.2.2 Use 50% Marble Slurry Concrete Blocks in Non-Load Bearing Structures

Results of usage of marble slurry shows that although 50% replacement of slurry with sand gives higher 7 days compressive strength values than other percentages but still this strength is far less than ideal compressive strength for using in load bearing structures which ranges from 2500 psi to 4000 psi. Therefore, it is recommended to use marble concrete blocks (50% replacement of sand) in non-load bearing structures / curtain walls, animal keeping huts, boundary walls, curb stones, labor accommodation at construction site, low cost housing projects, godowns (warehouses) and for construction of front line temporary defences. It will also economise the process of blocks construction as marble slurry can be collected free of cost from dumping points. As discussed earlier, replacement of 50% sand with marble slurry would save at an average of Rs 65000/- per month.

5.2.3 Use Recycled Wastewater for Economization of Marble Production

It is recommended that EPA should made it mandatory for marble processing units to construct re sedimentation tank. Recommended size of re sedimentation tank is (6 x 3 x 3) m. Capacity of re sedimentation is 54000 litres which can supply water to OHWT of 32621 liters capacity. 415 ft^3 volume of marble slurry can be settled per day and it will need extraction after 5-7 days. According to a research, 90% of slurry gets settled within 1 hour of detention. However, to achieve better results, 2 hours of detention time is recommended here. After 2 hours, marble slurry gets settled and wastewater is ready to be reused. Moreover, in order to achieve quick settlement within 25 minutes, a coagulant 'Ferric chloride' can also be added. After its necessary filtration, recycled wastewater can be pumped up to OHWT. Height of OHWT from re sedimentation tank is 70 ft and it takes 38 minutes for 1 x 5 hp water pump to fill OHWT. Use of recycled water economizes the marble production process as it reduces 299 units of electricity consumption per month, resultantly saving Rs 7584/- per month. Moreover, recycled water also reduces pressure from already scarce groundwater source and serves the same purpose with low cost.



(**Figure 18.** Recommended Wastewater Recycle Plan)

5.3 Conclusion

From recycling perspective, there were no studies conducted to present a systematic way of utilizing marble waste products. In this context, initiative of recycling potential of marble industry effluent, presents itself as an important vector in dissemination of sustainable thinking and will hopefully contribute to the effective utilization of waste products, economization of marble processing and bringing environmental improvements. This research concludes that marble industry has a great recycling potential, but this aspect had been neglected since decades. Awareness and attention to this aspect will not only lead to effective utilization of marble slurry in preparation of low-cost concrete blocks but will surely reduce air pollution manifolds. Apart from this, our rivers and canals are a main source of agriculture and if marble waste is dumped in rivers, it can adversely affect water quality being used in agriculture and is also a source for degradation of aquatic fauna. Recycling of wastewater also lead to economizing marble processing by reducing electricity consumption.

ANNEXURE A

Marble Units

No:	Version: B	Date: 21 May 2004	Page 6 of 14

Environmental Assessment Checklist

Section I: Project Description

File No ________________________ (To be filled by EPA)

Date ________________________

General Information

1. Project Name or Title ________________________
2. Project Proponent (Department or Organization) ________________________
3. Address ________________________
4. Telephone ________________________
5. Fax ________________________
6. E-mail ________________________
7. Representative of the Proponent ________________________
8. Designation ________________________
9. Name of the person who conducted this assessment ________________________
10. Designation ________________________
11. Qualification ________________________

Project Information

12. Project Location ________________________
13. Cost of the Project ________________________
14. Area of the proposed land for the plant

    Total ________________________ m^2

    Proposed covered ________________________ m^2

    Open space ________________________ m^2

15. Brief description of the plant ________________________

    ____

    ____

    ____

    ____

Please attach a plot plan of the proposed project site showing the location of the key structures, access, utilities, units, etc.

16. List key equipment of the plant______________________________

17. Design production capacity of the unit __________________________
18. Number and qualification of required staff to run the unit? ______________
19. What will be the expected water requirement for the unit? ___________ m^3/d
20. What is the proposed source of water? __________________________
21. Where will the wastewater from the unit be disposed? _________________
22. Describe the type of material that will be discharged with the wastewater? ___
23. Please describe any treatment system for the wastewater planned? ________
24. Type and quantity of raw material for the unit? ______________________
25. What is the expected source of the raw material? ____________________
26. What are the expected operating hours? __________________________
27. Is night shift planned? ______________________________________
28. How many vehicles carrying raw material and finished product are likely to enter or leave the unit daily? _____________________________

Construction

29. Who owns the proposed land for the project? _______________________
30. What is the present use of the land? ____________________________
31. Are there any squatter settlements on the land? ____________________

    If yes, please specify

    Number of settlements___________________________________

    Will any compensation be paid to them? __________________________
32. Are there any structures on the proposed site now? ☞ Yes ☞ No
33. If yes, will any structure be demolished? ☞ Yes ☞ No
34. If yes, where the demolition waste will be disposed? __________________
35. Are there any trees on the proposed site? ☞ Yes ☞ No
36. Will any tree be removed? ☞ Yes ☞ No

If yes, how many?______________________________________

37. Period of construction (start and end dates)______________________

38. What major construction equipment (dozer, grader, crane, etc.) will be used?

____

39. Is construction work during the night planned? ☞ Yes ☞ No

Section II: Screening

Is the proposed project located in an ecologically sensitive area?

☞ Yes ☞ No

Is the total cost of the proposed project Rupees 10 million or more?

☞ Yes ☞ No

If the answer to any of the above questions is yes, then the project would require an initial environmental examination or an environment impact assessment. Refer to the Pakistan Environmental Protection Agency Review of Initial Environmental Examination and Environment Impact Assessment Regulations, 2000 for appropriate category.

Section III: Environmental Profile

1. Describe the terrain of the project area:
   - ☞ Flat or Level (Slope < 3%)
   - ☞☞ Level to moderately steep (Slope 3%-30%)
   - ☞☞ Moderately steep to mountainous (Slope > 30%)
2. Are there signs of soil erosion or landslide anywhere within 500 m of the proposed site?
   - ☞☞ Yes
   - ☞☞ No

   If yes, please describe (where, nature)________________________

   ____
3. Is there any surface water body (river, canal, stream, lake, wetland) within 1,000 m of the proposed site?
   - ☞☞ Yes
   - ☞☞ No

8. Please provide the traffic count for all main roads adjacent to the proposed site or roads that will provide access to the site. The count should be based on data collected, for both directions, on at least three typical working days. Use the following format:

Road ________________ Count Location ________________________

	6:00 am-9:00 am	9:00 am-12:00 noon	12:00 noon-3:00 pm	3:00 pm-6:00 pm	6:00 pm-9:00 pm
Large vehicles (trucks, buses, tractor trolleys, Minibuses)					
Medium sized vehicles (Suzuki pickups, cars, jeeps, taxis)					
Small vehicles (Rickshaws, motorcycles, scooters)					
Slow vehicles (animal-driven carts, tongas)					
Others					

(*Please add additional sheets for every road*)

9. What is the present land use in the vicinity (roughly a radius of 500 m) of the proposed site?

	Residential (Thick, Moderate, Sparse)	**Commercial** (Office, Shops, Fuel Stations)	**Open Land** (Parks, Farmlands, unutilized plots, barren land	**Sensitive Receptors and Sites of Cultural Importance**	**Other**
Description					

(*Please attach a map of the proposed project site and indicate roughly the area that you have considered for this evaluation*)

If yes, describe each water body:

Name (including type, ie, river, canal or stream)	**Dimensions**	**Status and Uses** (Is it polluted? Is domestic or other wastewater discharged to it? What are its uses, eg, agriculture, domestic, industrial, washing, fishery

4. Is there any groundwater well on the proposed site or within 500 m of the proposed site?

☞☞ Yes

☞☞ No

If yes, describe each well:

Type (Dug well, tube well, hand pump	**Location** (Village, road, mohalla, etc. and distance from the site)	**Depth and Yield**	**Uses** (Drinking, agriculture, domestic, industrial, washing, livestock)

5. Based on the interview of the surrounding population or a wildlife expert, is any form of wildlife found on, or around the proposed site of the project?

☞ Yes ☞ No

If yes, please describe ______________________________________

____

Person Interviewed_____________________________________

6. Are there any existing trees or vegetation on the proposed site?

☞ Yes ☞ No

If yes, how many?_____________________________________

7. Are there any reserved forest or protected area within 1,000 m of the proposed site?

☞ Yes ☞ No

If yes, please describe? ________________________________

10. For any agricultural farmland on the proposed site and a radius of 500 m around it, provide the following information:

    Main crop(s) and average yield ______________________________

    Source of irrigation water ______________________________

    Area affected by salinity or water logging ______________________________

11. Please describe all the sensitive receptors within 500 m of the proposed site:

Type (schools, colleges, hospitals, and clinics)	**Name**	**Size** (Number of students or number of beds)	**Location** (Village, road, mohallia, etc.)	**Distance from Site**

12. Roughly, how many houses are within a radius of 500 m of the proposed site?
    ____

13. What proportion of the houses in the area are *pukka, semi-pukka, and* kutcha? ______________________________

14. How are the general hygienic conditions of the project area?

    ☞☞ Generally clean

    ☞☞ Fair

    ☞☞ Poor

15. Is there any bad odor in the project area?

    ☞☞ Yes

    ☞☞ No

    What is the source of the odor? ______________________________

16. What are the main sources of income of the surrounding community? ______
    ____

17. Is there any site of cultural importance (graveyard, shrine, mosque, archeological site) within 1,000 m of the proposed scheme?

    ☞☞ Yes

    ☞☞ No

    If yes, please describe? ______________________________

Section IV: Impact Assessment

Potential Negative Environmental Impacts	*Tick, if relevant*	*Mitigation Measures*	*Tick, if proposed*	*Monitoring*
Siting	☞	Factory will not be located in an industrial zone	☞	
		Factory will not be located within 500 m of any community, educational institution or health facility		
Traffic	☞	Plant is located such that ingress of heavy vehicles does not block the traffic	☞	
Dust	☞	Dust containment enclosures will be provided	☞	
Noise	☞	Noise wall will be built	☞	
		Evening and late night operation of material and product trucks will be avoided	☞	
Wastewater	☞	Volume and strength reduction of the effluent is to be achieved by preventing mixing of waters from washing activities and processing activities	☞	
		Liquid effluent is to be treated by sedimentation process meaning subjecting the effluent to flow through settling tanks	☞	
		Effluent is to be treated by coagulation that is adding any coagulant to the settling tanks	☞	
		Effluent is to be treated by coagulation and filtration	☞	
Occupational safety	☞	Workers will be provided with protective equipments	☞	

Section V: Undertaking

I, ______________________________ (*full name and address*) as proponent for ______________________________ (*name, description and location of project*) do hereby solemnly affirm and declare:

1. The information on the proposed project and the environment provided in Forms I, II and III are correct to the best of my knowledge
2. I fully understand and accept the conditions contained in the Guidelines for ____ (*name, number and version of the guidelines*)
3. I undertake to design, construct and operate the project strictly in accordance with the project described in Form I, submitted with this undertaking.
4. I undertake to implement all mitigation measures and undertake monitoring stated in Form IV, submitted with this undertaking.

Date _______

Signature ____________________

Name ____________________

Designation ____________________

(with official stamp/seal)

Witnesses:

	Signature	Name	Address
1	____________	______________	____________________
2	____________	______________	____________________

ANNEXURE B

PHE LABORATORY MCE RISALPUR CANTT

Water Quality Analysis Report

Report Serial No:

Client Sample Code:

Sampling Receipt Date:

Client Name and Address: Marble Industry

Reporting date: 9-3-2020

Terms and Conditions:

The Following Results of PHE Lab are verified as accurate only for the parameter tested. The following analysis Report is not valid for court use or any business publicity. The PHE Lab does not accept any responsibility for the sample collection procedure if collected by the client. The PHE Lab reserves the right to reject any sample(s) for analysis without assigning any reasons. The analysis Report will be issued after the payment of analysis charges. In all cases, the analysis report of PHE Lab will be considered final.

Ser#	Parameter	Unit	WHO Permissible Limits	Results
1	pH	-	6.5--8.5	6.7
2	Electric Conductivity	µS/cm	--	–
3	Turbidity	NTU	5	–
4	Color (True)	Unit	5	1270 (Apparent color).
5	Alkalinity	mg/L	--	–
6	Total Hardness	mg/L	500	–
7	Chloride	mg/L	250	–
8	Sulphates	mg/L	250	–
9	Phosphates	mg/L	--	–
10	Nitrate	mg/L	10	–
11	Total Dissolved Solids (TDS)	mg/L	1000	1445
12	~~Arsenic~~ Total Suspend Solids	~~µg/L~~ mg/L	150	370
13	Iron	mg/L	0.3	–
14	Chromium	µg/L	--	–
15	Dissolved Oxygen	mg/L	--	5.3
16	~~Total Coliform~~ BOD (80	~~MPN/100 mL~~	80 ~~Nil~~ mg/L	115
17	~~Fecal Coliform~~ COD (150)	~~MPN/100 mL~~	150 ~~Nil~~ mg/L	190

For

(OIC PHE Laboratory)

REFERENCES

- Alzaboon, K. K. and Tahat, M. (2009) Recycling of stone cutting waste in floor tiles and New York, p 163.
- Andre, A., de Brito, J., Rosa, A., & Pedro, D. (2014). Durability performance of
- Angotzi, G., Bramanti, L., Tavarini, D., Gragnani, M., Cassiodoro, L., Moriconi, L., Saccardi, P., Pinto, I., Stacchini, N. and Bovenzi, M. (2005). "World at Work: Marble Quarrying in Tuscany". Occup. Environ; 62: 417-421
- Anonymous. 2001. The NEWS International, 2001.
- Bacarji, E., Toledo Filho, R. D., Koenders, E. A. B., Figueiredo, E. P., & Lopes, J. L.
- Camici, G., Castagna, P., Leva, G., Messina, S., Poletti, G. F. and Vergazzoli, P. C. (1978). "Environmental Health Risk Working shop". Ann Ist. Super Sanita; 14 (3):547.
- Chillers, J. and A. Henrik. 1996. Effect of concrete fillers. Construction and Building Materials, 45, 1-10.Concrete incorporating coarse aggregates from marble industry waste. Journal contaminated water. Global Water Hazards. Cradle for sustainable development.1st edition, Elsevier Academic Press.
- Domopoulou, A. E., Gudulas, K. H., Papastergiadis, E. S., & Karayannis, V. G. (2015). Coagulation/flocculation/sedimentation applied to marble processing wastewater treatment. *Modern Applied Science*, *9*(6), 137.
- El Haggar, S. (2007). Sustainable industrial design and waste management: cradle-to
- El-Gammal, M. I., Ibrahim, M. S., Badr, E. A., Asker, S. A., & El-Galad, N. M. (2011). Health risk assessment of marble dust at marble workshops. *Nat Sci*, *9*(11), 144-154.
- Estate, Jamrud Road, Peshawar, Pakistan.
- for gainful utilization of marble slurry in india. Centre for development of
- Gokaltun, E. (2011). An Experimental Work on Atmospheric Corrosion Formation
- https://www.cabdirect.org/cabdirect/abstract/20133364056
- Kearey P (2001) Dictionary of Geology, Penguin Group, London
- Leikin E, Zickel-Shalom K, Balabir-Gurman A, Goralnik L, and Valdovsky E (2009). "Caplan’s Syndrome in Marble Workers as Occupational Disease". Harefuah 148: 524–526.
- Li, L. G., Wang, Y. M., Tan, Y. P., Kwan, A. K. H., & Li, L. J. (2018). Adding granite dust as paste replacement to improve durability and dimensional stability of mortar. *Powder technology*, *333*, 269-276.
- M. P. (2013). Sustainability perspective of marble and granite residues as Mineral Testing Laboratory (MTL). Environmental Cleanup Demonstration Model in
- Nafees, M. (2010). Role of Kabul River in Socio-economic Activities and Associated Environmental Problems. *Central Asia (1729-9802)*, (67).
- Noreen, U., Ahmed, Z., Khalid, A., Di Serafino, A., Habiba, U., Ali, F., & Hussain, M. (2019). Water pollution and occupational health hazards caused by the marble industries in district Mardan, Pakistan. *Environmental Technology & Innovation*, *16*, 100470.
- Pilkington, A., Maclaren, W., Searl, A., Davis, J. M. G., Hurley, J. E., Soutar, C. A., Pairon, J. C., and Bignon, J. (1996). "Scientific Opinion on the Health Effects of Airborne Crystalline Silica".

IOM report TM/95/08. Edinburgh, Institute of Occupational Medicine. Ref Type: Report production. International Journal of Theoretical & Applied Sciences, 1(1): 64-

- Shah, W. (2016). *Life cycle assessment of marble industry for cleaner production technology as a pollution prevention measure* (Doctoral dissertation, UNIVERSITY OF PESHAWAR).
- Simsek, C., Karaca, Z., Gemici, U., & Gunduz, O. (2005). The assessment of the impacts of a marble waste site on water and sediment quality in a river system. *Fresenius Environmental Bulletin*, *14*(11), 1013-1023.stones. http://www.cdos-india.com/Papers/technical.html.
- The Marble Industry, Final Report (June 2000-May 2001). 164C Industrial
- Tjoe-Nij, E., Burdoff, A., Parker, J., Attfield, M., Van Duivenbooden, C. and Heederik, D. (2003). "Radiographic Abnormalities among Construction Workers Exposed to Quartz Containing Dust. Occupational and Environmental Medicine, 60: 410-417
- Vijayalakshmi, V. Singh, S. & Bhatnagar, D. (2003). Developmental efforts in R & D Water Quality Assessment.