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Marble Production and Environmental Constrains: Case Study from Zarqa Governorate, Jordan

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Abstract

Along the rapid growth of human needs in many sectors, a significant decrease in the availability and viability of the natural resources is always faced. The high volume production is always associated by considerable amount of waste materials that may adversely impacts the surrounding environment. One of the major waste generating industries is the marble production industry, by which ornamental stone manufacture acquires special mitigation process and environmental assessment to minimize the negative environmental impacts that may generate. Efforts on bypassing such dilemma were intensified looking for new regulations and legislations to minimize and reuse the generated waste. This paper addressed the possible environmental impacts that might generate from ornamental stone production as a rapid growth industrial sector in Jordan and to review the adequacy of Jordanian environmental legislations in controlling the environmental protections norms associated with such industry. Preliminary environmental impact assessment was conducted at eight marble manufacturing enterprises distributed in Zarqa Governorate at north-west of the capital city Amman. The assessment included testing of major chemical and physical environmental resources, products and byproducts generated from each establishment according to the production stages and in accordance to the Jordanian environmental regulations and legislations in force. Results indicated that noise levels were above the International Standards, which require a special attention. In terms of water and land resources, ornamental waste products; estimated to be around 10% of the prime material consumed; may form a source of contamination through the unsuitable solid and liquid waste disposal strategies adopted by the inspected manufacturers. The paper addressed the implementation of chemical-stabilization wastewater treatment units to treat wastewater before disposing it into the domestic sewage system, whereas solid waste should be disposed only in specialized industrial plants.

Keywords: Marble industry; Environmental legislation; Waste Disposal; Environmental Impact Assessment; Environmental management; Zarqa- Jordan;

1. Introduction

Along the rapid growth of human needs in many sectors, a significant decrease in the availability and viability of the natural resources was always faced. Neither the less, the high volume production is always associated by considerable amount of waste materials, which may adversely impacts the surrounding environment. Efforts on bypassing such dilemma were recently intensified in many countries and international establishments looking for new regulations and legislations to minimize and reuse the generated waste (UMTC, 1995; OECD, 1997).

One of the major waste generating industries is the marble quarry and production industry by which around 70% of this precious mineral resource is wasted in the mining, processing, and polishing procedures. Around 40% of marble waste is generated world widely during quarrying operations in the form of rock fragments and being dumped either in nearby empty pits, roads, riverbeds, pasturelands, agricultural fields, or landfills leading to wide spreading environmental pollution (Çelik, 1996; Akbulut and Gürer, 2003).

Jordan is one of the leading marbles producing countries in the Middle East, where marble production sector in Jordan contributes about 18.7% of Gross National Product (GNP) (DOS, 2000). Recently, marble production in Jordan is considered a key supporter for hard currencies along 66% industrial exports contribution of gross national exports (DOS, 1998). Internationally, marble production and consumption in Europe has been continuously increasing over the last two decades with an annual increase rate of 7% (Harold and Taylor, 1993) by which projected demand for dimensional marble was estimated to be 600,000 tons for the year 2000 (Official Gazette, 2000).

Zarqa Governorate in Jordan, the third biggest city after the capital city Amman and Irbid in size and population

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are considered the largest industrial zone by which half of Jordanian industrial establishments' lies within the Zarqa Governorate (DOS, 2004). The number of Jordanian industrial establishments had reached around 23,000 in 1997 (Jordanian Sanitary Drainage System Instructions, 1998). In addition, and according to the Zarqa industrial chamber (2002), there are about 23 marble manufacturing plants of small and medium sized enterprises, which are centralized within the southwest of Zarqa city.

Growing concerns for environmental protection against industrial impacts on human health has motivated many studies to activate and legislate environmental protection laws. According to Zarqa Governor (the environmental status of Zarqa Governorate Workshop, 2006), the industrial plants within Zarqa Governorate claims the responsibility for about 75% of the total pollution of the Kingdom, where various pollution sources are contaminating most of the Zarqa natural resources. The main pollution sources are derived from industrial enterprises that pollute air considerably by gas emission from existed power plant and fuel refinery while overspill and bad management of existed wastewater treatment plants are polluting groundwater considerably. Thus, many regulations and legislations were enforced in all industrial sectors to protect the existing natural resources. However, some specific industries were not included within these legislations. Manufacturing of Ornamental stone is one of these industries that need to be evaluated to determine the certain norms required to regulate their action and to control the possible generated environmental impacts.

The main objectives of this study were to evaluate the possible environmental impacts that might generate from ornamental stone production as a rapid growth industrial sector in Jordan and to review the adequacy of Jordanian environmental legislations in controlling the environmental protections norms associated with such industry. More specifically the study assesses through simple preliminary EIA for the major effective impacts of wastewater and solid waste disposal strategies adopted in marble manufactures along other environmental norms.

2. Review of Some Jordanian Related Regulations and Legislations

The concerned environmental Jordanian legislations dealing with environmental aspects are regulated by five ministries: the Ministry of Environment (ME), Ministry of Agriculture (MA), Ministry of Water and Irrigation (MWI), Ministry of Planning (MP), and Ministry of Health (MH).

Although marble industry is not included directly in TEP 2003 and EPL 1995 legislations, the following legislations and regulations can be related through one or more of environmental norms:

1. According to ME in concern of water quality, Article (17) of the (EPL) - 12 of 1995, provides that the corporation shall, in coordination with the competent authorities, undertake the assurance of general standards for water in all its usages and examination of water sources with respect to pollution with respect to the water sector.
2. According to ME in concern of waste disposal, Article (26) of the (EPL) number 12 of 1995, prohibits the dumping, disposal of and piling up of any substances that are harmful to the environment whether solid, liquid, gaseous, radial, or heat in water sources, or the storage of any of these substances in close proximity to the water sources and within a distance to be specified by the Minister (the Minister of Municipal, Rural and Environmental Affairs) in accordance with the recommendations of the General Manager of the Corporation.
3. According to land use classification accomplished by the MA and enforced by the MP the *Agriculture Law Number 20 For The Year 1973* (Official Gazette, 1973) and supported by the *Law Of Managing The Country Properties Number 17 For The Year 1974* (Official Gazette, 1974), prohibits land use for other non-classified purposes (i.e. lands that are classified according to their potential capability as agricultural lands can not be used for industrial activities).
4. According to MP, the *Law of Regulating Cities, Villages and Buildings Number 79 for The Year 1966* (Official Gazette, 1966) and its modifications, and *Municipalities Law Number 29 for The Year 1955* (Official Gazette, 1955) prohibits the establishment of any industrial activity within pedestrian city limits, thus, industrial establishments are forced to be held at the industrial cities in accordance to the *Industrial Cities Institution Law number 59 for the year 1985* (Official Gazette, 1985).
5. According to ME in concern of air emission protocols, *Traffic Law number 14 for the year 1984* (Official Gazette, 1984) provided a standards for the permitted emission level of each gas.
6. According to MH in concern to health, *General Health Law number 21 for the year 1971* (Official Gazette, 1971) states that "the Ministry of Health shall be responsible for all matters pertaining to heath in the Kingdom including (i) The provision of preventive and curative health care, (ii) Prevention of contagious diseases, (iii) Promotion of health awareness and medical culture through available means, and (iv) Establishment and management of all types and levels of educational institutions for medical professions and setting their curriculum, appointing their teaching staff, and issuing certificates for their graduates provided that educational institutions for medical professions that exist at the time of the enactment of this Law shall be deemed established in accordance with its provisions".

In addition, according to the subsection TEP law article 13-B, existing factories have to introduce mitigation actions that gradually minimize the negative environmental impacts with the support of the ME. Since all existed factories within the Zarqa Governorate were operating before the TEP law came to force, it is environmentally relevant to evaluate the performance of the existing marble industry through conducting EIA analysis and to provide proper management plan as proposed to such cases. Lately, the article 13.A of the TEP law (annex 2 number 11.B for extracting industries and surface mining and their derived industries) states that “Any establishment, company, or entity, or any enterprise the provisions of this law come into force, and which

conducts an activity that might adversely affect the environment, shall be bound to prepare an evaluation study on the environmental effect of its projects and submit it to the ministry, in order to take the appropriate resolution in its respect". Finally, article 13-B states "the minister shall be entitled to request any establishment, company, enterprise, or party, which conducts any activity that affects the environment, to prepare an evaluation study on the environmental effect of its projects."

3. Materials and Methods

The manufacturing of marble involves cutting and finishing marble obtained from quarries, where specific dimensional marble is prepared for various uses in specialized mills equipped with saws, polishing machines, and others. Marble sawing equipment includes large circular saws, where various types of diamond and other equipment are used for smoothing, polishing, and edging the raw marble. The marble production process includes several steps. In the first phase, blocks (usually have a weight between 15 and 20 Metric Ton) and slabs are stored and deposited in the park of prime materials by means of two bridge cranes for great tonnage (See Figure 1). Saws (gang saw or slab cutting machines) are used for cutting blocks into more governable units (slabs) for the following processes of production (See Figure 2).

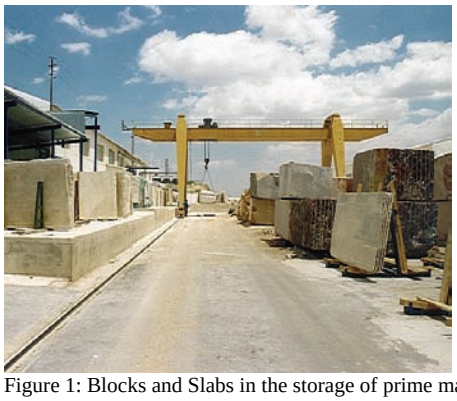


Figure 1: Blocks and Slabs in the storage of prime materials

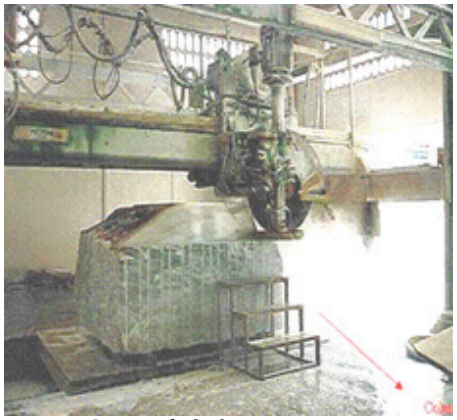


Figure 2: Cutting of Blocks

According to direct inspection of the manufactures, the cutting process is carried either in dry or in wet medium. Slabs obtained are rough unpolished and appear in different formats and sizes (usually between two and 4 m width). A cutter is used next to obtain different sizes of flagstones of (60-cm × 30-cm × 2-cm dimensions). In some cases, flagstones are sold directly without polishing. However, a polish unit of chemical treatment is adopted followed by a refining process.

The study was conducted at the Zarqa Governorate at the Northwest of the capital city Amman. The biggest eight manufactures out of the 23 existed marble establishments have been environmentally assessed in detail to identify the environmental constrains and influences. Field survey as well as questionnaire fillings that is especially prepared for data collection to be considered as a response, with 34.8% response rate, the refusals to participate were 8 plants with a rate of 34.8%, the incomplete fillings were for 3 plants with a rate of 13.0%, and the withdrawals after contacts was 4 plants with a rate of 17.4%. The products and byproducts generated from each establishment have been assessed individually from environmental prospect according to the production stages and in accordance to the Jordanian environmental regulations and legislations in force.

The impacts of the marble manufacture can be estimated and evaluated according to production stage or process. Each process includes some action that adversely affects the environment through one or more environmental norm. For example the sawing or cutting phase involve noise effect and dust emission, while cutter and polishing phases involve chemical uses and contamination of water. However, the following list of aspects was assessed in detail; land take for the development and change of land use, impact on site characteristics during and after marble production operations, economic impacts during operation, social impacts, solid waste disposal, sewage system and volume of liquid wastes, private and public traffic on the way to the site, and air and water pollution during marble manufacture operations.

The final evaluation was based on raw material consumption and marble production (production index), energy consumption, water consumption and reuse, types and quantities of waste products, effluent water quality, particulate and gaseous emissions, and noise levels. Solid waste disposal was evaluated according to waste type while wastewater was assessed chemically through providing a monitoring program. Effluent water samples were collected and chemically analyzed for contaminants loads through a year monitoring program. In addition, noise levels were measured at each stage of production using sound level meters and noise dosimeters.

Finally, the paper addressed the significance of the impacts as evaluated and compared to the existed environment baseline, including alternatives and mitigation strategies distinguishing between impacts in form of positive or negative, reversible or irreversible, temporary or permanent, short term or long term, and direct or indirect.

4. Results and Discussion

4.1. Landtake and Change of Land Use

First, as inspected through the foundation records for the eight different marble manufactures, the existed establishments violate the *Agriculture Law Number 20 for The Year 1973* and the *Law of Managing the Country Properties Number 17 for The Year 1974* by being established on agricultural lands and not industrial ones. Neither the less, existed marble establishments also violated the *Law of Regulating Cities, Villages and Buildings Number 79 for The Year 1966* and *Municipalities Law Number 29 for The Year 1955* by being within pedestrian limits. Therefore, existed established marble companies had a permanent negative impact on land use leading to the loss of ecological habitats with negative effects on flora and fauna populations by reducing the green-agricultural spots and might increase the risk of agricultural contamination. The industrial chamber along the authorized ministries should adopt a mitigation process to translocate those existed establishments outside the pedestrian or agricultural limits.

4.2. Site Characteristics During and After Work Operations

According to field inspection of the surrounding areas for the marble establishments, marble production negatively and directly damaged the existing landform by intrusion of urban development and by loss of attractive features such as vegetation and hills. The general landscape features will be changed partially or totally depending on the size of the establishment as well as associated activity and location. From landscape point view, formation of edges, corridors, boundaries will be formed which in turn will block the connectivity between ecosystem components as a genetic resources for the adjacent habitat.

4.3. Social and Economic Impacts

Jordan is primarily an agrarian society. The agricultural sector accounted for 7% of GNP in 1991(DOS, 1991), a proportion which has gradually decreased as farm workers are drawn in from the land to serve the expanding construction and industrial sectors. To date, Jordan has lacked the detailed database on soil and land characteristics that is necessary to allow rational planning of land and water resources utilization, especially in setting priorities for the efficient use of the very limited surface water and groundwater reserves. Jordan is classified among few countries of the world with limited water resources and it is one of the lowest on a per capita basis. The available water resources per capita are falling because of population growth and are projected to fall from less than 160 m^3/capita/year at present to about 90 m^3/cap/year by 2025, putting Jordan in the category of an absolute water shortage. The scarcity of water in Jordan is the single most important constrains to the country growth and development because water is not only considered a factor for food production but a very crucial factor of health, survival and social and economical development.

Raw material consumption and production can be used as an indication for the intensiveness of manufacture day activity loads, thus the potential of daily pollution if contamination exists. Raw material consumption varies significantly along the eight manufactures ranging from 33 to 990 m^3/day (working day) with an average of 405.6 m^3/day and a standard deviation of 352.9 m^3/day (Table 1). According to the statistical analysis using JMP program (JMP IN, 2004); the huge variation of the standard deviation indicates the large variability between the marble manufactures in Zarqa Governorate given by a coefficient of variation of 87%.

Marble production also varied significantly from 28 to 890 m^3/day with a mean of 368.8 m^3/day, a standard deviation of 321.7 m^3 / day and a coefficient of variation between manufactures of 87.3% (Table 1). According to linear regression by forcing the origin pass using the JMP statistical program, the average marble production was proportional by around 90% to raw material consumption (i.e. for each one-m^3/day increase in the average raw material consumption, the production increases by 0.90 m^3/day), with a root mean square error of only 12.74 m^3/day. Subsequently, waste products calculated by the difference between raw material consumption and production, where ranging from five to 100 m^3/day, with an average of 36.9 m^3/day and a standard deviation of 33.9 m^3/day (Table 1). According to statistical analysis (Tables 2 and 3), the generated waste residues forms about 10% of the prime material entered in processing. However, the difference between raw material consumption and production is not necessary assigned as waste products but rather could be byproducts. According to site investigations, some of the generated residues derived from all marble manufacturing steps may reuse for other ornamental or construction appliances as garden landscaping, house floor flagstones and roads.

According to the surveyed income of the establishments, the gross annual return varied from 10,000 to 100,000 JD depending on the establishment size and trade. From economic standpoint, the marble production offers a positive impact by providing cash currencies and long-term benefits during operation. The local community of the village is of low standard living as surveyed. The average income of each family is less than 200 JD per month. Most the families hold at least four persons and increase up to 12 person per house (Un–published data from Zarqa Industrial Chamber and questionnaire answers). Due to fact that the existed lands are far from large cities and being classified as agricultural lands, the area is considered a rural village that is not urbanized yet. The presence of marble establishments within their limit in the theory of industrial development gave the rise for the local community for better living standard for increasing the cost of the land itself and provides working opportunities within the establishments with a wage level exceeding 200 JD a month. However, women contribution was not a matter of improve since the working environment and the cultural values required heavy-male actions. At the same time, educational levels were not a matter of concern. Therefore, one of the positive social impacts of such establishments away from environmental

consideration is the creation of job and opportunities as well as the activation of the business sector, which have positive effects on the economic welfare of the local population.

4.4. Energy Consumption

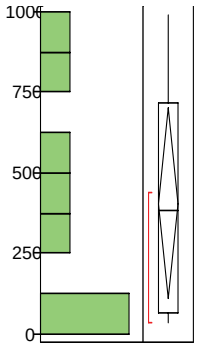
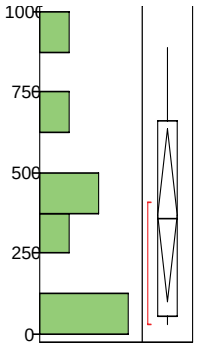
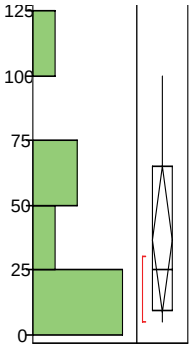
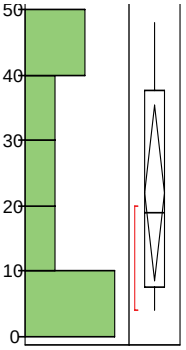
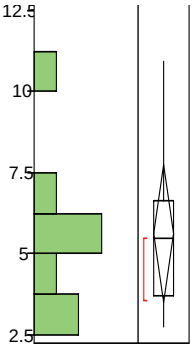
The utilized energy at the marble factories was only generated directly from electric source. No old fuel burning devices were detected at the sites, which in turn, minimize the environmental impact from energy consumption sources. Therefore, energy consumption is not a considerable focus of local environmental impact within this study. However, energy consumption was also variable between inspected manufactures by which the energy consumption varied from 2.7 to 11 KW/day with an average of 5.6 KW/day and standard deviation of 2.54 KW/day (Table 1).

4.5. Solid Waste Disposal

Wastes produced from marble manufacture can be categorized as either by-product or waste, in all cases; the wastes disposal should follow specific regulations according to type and quantity. Unfortunately, there are few regulations that control the disposal strategy of waste products. The TEP law within articles (6, 7, 13, and 17), and Article (26) of the (EPL) number 12 of 1995 state that environmentally detrimental waste disposal is prohibited to be dumped or disposed whether if it is solid, liquid, gaseous, radial, or heat in water sources in accordance with the recommendations of the General Manager of the Corporation and their disposal in landfills should be regulated by the Governorate authority.

The sources of the generated residues in marble manufacture can be categorized into (i) gravels and broken slabs, (ii) slurry and sludge, (iii) used oils and lubricants, and (iv) others (Table 4). According to European Community Regulations (CER), gravels, broken slabs and small-unwanted flagstone are classified as inert of code number (CER 010202 and CER 010406) by which they are formed from the process of refined cuttings, and rough dressing accumulating for 10% of the prime material entered into processing.

Table 1: Raw Material Consumption and Production for the studied marble manufactures

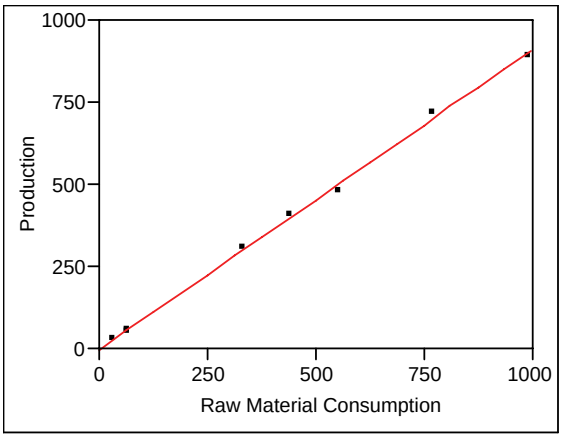
	Raw Materials Consumption (m^3/day)	Production (m^3/day)	Waste (m^3/day)	Water Consumption (m^3/day)	Utilized Energy (KW/day)
Manufacture # -1	66	57	9	7	5.5
Manufacture # -2	330	310	20	18	4. 2
Manufacture # -3	550	480	70	30	5. 5
Manufacture # -4	33	28	5	4	2.7
Manufacture # -5	770	720	50	40	7.1
Manufacture # -6	990	890	100	48	11.0
Manufacture # -7	66	55	11	9	3.6
Manufacture # -8	440	410	30	20	5. 5
Quintiles					
Mean	405.625	368.75	36.875	22	5.6181507
Std Dev	352.85527	321.67985	33.90928	16.044581	2.540933
Std Err Mean	124.75318	113.731	11.988741	5.6726159	0.8983555
upper 95% Mean	700.61939	637.68109	65.223868	35.413605	7.7424239
lower 95% Mean	110.63061	99.818912	8.5261323	8.5863948	3.4938775
Sum	3245	2950	295	176	44.945205
Variance	124506.84	103477.93	1149.8393	257.42857	6.4563406
Skew ness	0.5223071	0.4890057	1.0437163	0.5738727	1.3915138
Kurtosis	-0.905606	-0.99907	0.0996302	-1.017245	2.5727495
CV	86.990513	87.235215	91.95737	72.929912	45.227214

Their disposal strategy adopted by the manufactures varied according to the quantity of waste. Some manufactures were investigated to dispose their small-quantity wastes illegally on roadsides while others were disposing their large-waste loads into specialized landfills. However, obligation of disposal in specific landfills is predetermined by the local municipality as indicated by the Jordanian Law of Regulating Cities, Villages and Buildings number 79 of 1966 (Official Gazette, 1966) and its amendments.

Slurry, on the other hand, is prohibited to be disposed into the sanitary drainage system according the Sanitary Drainage System Law number 1 of 1998 (Official Gazette, 1998), where it is forced to implement a pretreatment plant to eliminate solids from liquid. According to this study, on average of only 2 m^3 /day of slurry or sludge were produced from marble manufacture, where mud produced before polishing were dried and packed for liming agent, animal feedings, and construction purposes, while mud produced just after polishing process were disposed into the sanitary drainage system. This type of mud requires more detailed investigation for defining the best disposal strategy.

The second type of waste is the used oil produced from cutting units, lawn mower, polisher, and wheelbarrows. According to Jordanian legislation as well as the European Community Regulations, used oil is considered as dangerous waste which require a special management if the quantity exceeds the standard limits of one m^3/year. According to inspected marble sites, the quantity of used oil has reached a maximum of 500 l/year (year is 200 working days), thus, their disposal strategy in Jordan compiles the European regulation by which used oil quantity must be declared by the local authority and should be stored in special containers and collected by oil refiner companies. In all cases, it is prohibited to dispose used oil in the municipal drainage system as indicated in article 3-G of the Jordanian Sanitary Drainage System Instructions of 1998 and the directive number 66 for the year 1994 (Official Gazette, 1994)

Table 2: Bivariate Fit of Production By Raw Material Consumption



Linear Fit
Production = 0 + 0.909825 Raw Material Consumption

Summary of Fit

RSquare	.
RSquare Adj	.
Root Mean Square Error	12.74374
Mean of Response	368.75
Observations (or Sum Wgts)	8

Analysis of Variance

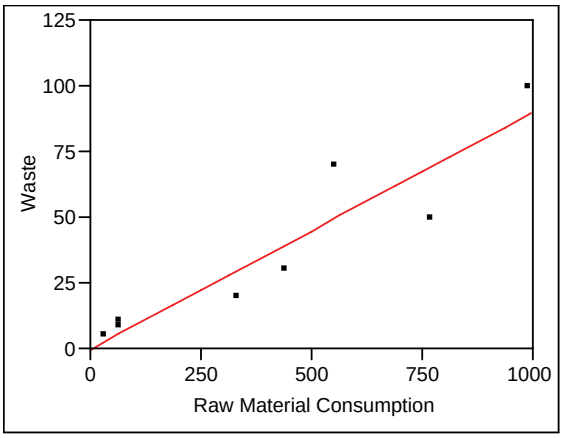
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1811021.2	1811021	11151.4
Error	7	1136.8	162	Prob > F
C. Total	8	1812158.0		<.0001

Tested against reduced model: Y=0

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept	Zeroed	0	0	.	.
Raw Material Consumption		0.909825	0.008616	105.60	<.0001

Table 3: Bivariate Fit of Waste by Raw Material Consumption



Linear Fit
Waste = 0 + 0.090175 Raw Material Consumption

Summary of Fit

RSquare	.
RSquare Adj	.
Root Mean Square Error	12.74374
Mean of Response	36.875
Observations (or Sum Wgts)	8

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	17790.179	17790.2	109.5434
Error	7	1136.821	162.4	Prob > F
C. Total	8	18927.000		<.0001

Tested against reduced model: Y=0

Parameter Estimates

Term		Estimate	Std Error	t Ratio	Prob>|t|
Intercept	Zeroed	0	0	.	.
Raw Material Consumption		0.090175	0.008616	10.47	<.0001

Table 4: Types of Wastes produced from Marble Manufactures

Denomination	Classification	Metric	Storage
Flagstones	Byproducts	10% of raw material	In-Plant Disposed area
Mud's or Slurry	Inserts	0.7 m^3/year	In-Plant Disposed area
Flocculent agents (PRAESRO, 2540)	Dangerous	6.57 m^3/year	Special Containers
Plastic	Not dangerous	0.2 ton/year	Containers
Wood	Not dangerous	0.2 ton/year	Containers
Oil lubricant	Dangerous	< 1 m^3/year	Special Container
Powder	Dangerous	varies	

Plastic and wood are minor waste type produced from marble manufactures by which they are used as complementary materials as holders or packing materials. Both of two waste types did reach a maximum of 0.2 ton per working year where they are stored and sold by the end of the year to some private companies under the authority of the Zarqa Governorate.

Disposal of solid waste as inspected, when inefficient, might lead to its accumulation affecting therefore the comfort and general health conditions of the local community. Thus, regulation actions should take more control in forcing the marble establishments to dispose their solid wastes in specialized industrial landfills outside the pedestrian areas.

4.6. Sewage System and Volume of Liquid Wastes

Massive amount of water were used for cooling, cutting, calibrating and polishing machines (See Figure 3). Water consumption varied from four to 48 m^3/day with a mean of 22 m^3/day and standard deviation of 16 m^3/day (Table 1). Some manufactures collects wastewater produced in cutting process through special drains to be used for further applications after solid removal by mechanical treatment were collected in a settling tank for recycling (See Figure 4), by which the recycled water are collected in a reservoir tank, while the sludge is disposed in landfills outside the processing plant.

Table (5): Chemical analysis mean values for one-year monitoring program for marble wastewater effluents

Manufacture	#1	#2	#3	#4	#5	#6	#7	#8	JS[1]
pH	8.30	8.02	8.31	8.15	8.24	8.25	8.04	8.15	6.5-9.0
EC (dS/m)	3.21	2.32	2.73	2.69	3.98	2.33	3.98	3.33	-
TDS (mg/ L)	2693.38	2623.71	2821.95	2655.43	3253.81	3385.27	3352.21	3281.17	3000
Hardness (mg/ L)	1268.62	1515.31	1553.05	1104.57	1026.19	934.73	2026.19	1934.73	1500
HCO_3	367.2	402.1	356.1	385.5	406.5	365.8	401.5	386.5	-
Ca^{2+} (mg/ L)	321.44	434.25	245.2	280.25	275.2	465.8	324.1	354.1	-
Mg^{2+} (mg/ L)	240.2	250.8	262.5	312.3	272.1	330.2	341.1	332.5	-
K^+ (mg/ L)	23.5	24.1	35.2	30.4	28.6	36.2	31.4	28.4	-
Cl^-(mg/ L)	175.6	211.1	222.6	144.4	244.9	166.2	344.9	366.2	500
NO_3^- (mg/ L)	3.58	4.86	0.77	0.22	1.55	0.88	1.55	1.88	12
SO_4^{2-} (mg/ L)	287.1	239.1	245.1	304.3	291.3	239.1	391.3	442.1	500
Na^+ (mg/ L)	273.12	285.5	441.3	343.2	415.2	356.4	455.5	421.2	-
Al^{3+} (mg/ L)	2.11	2.51	2.34	3.21	2.01	2.34	3.21	3.54	5
Fe (mg/ L)	0.04	0.05	0.04	0.07	0.08	0.04	0.06	0.05	1
Mn (mg/ L)	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.2
Zn (mg/ L)	0.04	0.06	0.07	0.05	0.06	0.04	0.05	0.04	15
Cu (mg/ L)	0.1	0.05	0.12	0.13	0.04	0.04	0.05	0.1	2
Cr (mg/ L)	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.01	0.1
Pb (mg/ L)	0.01	0.01	0.01	0.00	0.01	0.01	0.00	0.01	0.1
Cd (mg/ L)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Ni (mg/ L)	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.2
Se (mg/ L)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
BOD_5 (mg/L)	45	43	35	26	35	42	24	47	50
COD (mg/L)	20	25	22	23	24	32	22	24	150
Total Coliform (MPN/100ml)	285	154	125	218	142	165	224	217	1000
Fecal Coliform (MPN/100ml)	101	104	132	145	152	120	147	125	1000

1 Jordanian Standards 202/1991 for Industrial Wastewater disposal.
(_) Undetermined: it depends in its determination on standard and general stipulations.


Figure 3: Polisher


Figure 4: Settling Tank

Generally, the massive water produced at the end of the production is either recycled in order to be reused again for the same purpose or disposed into the domestic sewage system (municipal network) that flows into the nearby Assamra Waste Water Treatment Plant (WWTP). In both conditions, the MWI should undertake the assurance of general standards for water in all its usages and examination of water sources with respect to pollution according to Article (17) of the (EPL) number 12 of 1995 by which the effluent quality of the marble manufacture must fit the Industrial Wastewater Standard Specification (Jordanian Standard No.202 of 1991), in order to be recharged to wadis, or to reuse in agriculture and industry, or to be used for artificial groundwater recharge.

From environmental point view, wastewater should be disposed into industrial treatment plants located within the same Governorate and not into the domestic WWTP. Three out of eight manufactures where inspected to violate the wastewater disposal strategy directing their effluents into the domestic sewage system. The eight manufactures should implement a preliminary chemical-treatment plant system at the plant area before disposing into the industrial sewage system. The chemical-treatment plant system should include a settling reservoir with a chemical stabilization unit to allow the reuse of water for cooling the machines only. The sludge obtained after the chemical stabilization unit is pressed by high-pressure machine to retrieve absorbed water, while cubed solid sludge as a solid waste is then transported outside the processing plant.

4.7. Private and Public Traffic

Traffic is usually an issue for urban development. The baseline at the inspected sites includes either one large highway crossed by unsealed roads or only sealed cross by non-sealed roads. Neither railways nor ports were inspected at the village or nearby forcing most of the transportation to be achieved by large vehicle. The existing traffic flow before the establishment is much lower since the village is only of local agricultural lands. The existence of marble infrastructure had anticipated in more traffic flow especially during operation with large diesel type vehicle, which moves according to establishment production to either 10 or more frequent moves a day. The presence of such vehicles requires safety issues for roads and driving controls. Commonly, diesel vehicles emit SOX, NOX, CO_2, CO and Hydrocarbons that are considered hazardous pollutants. The gaseous emissions to air from vehicles may result in negative effects on the health of the local population. The negative impact can be only resolved by the mitigation action of the marble manufactures translocation to industrial zones, otherwise, reduction in traffic may cause the reduction in production, and therefore cash return.

4.8. Air Pollution

Particulate emissions or fugitive dusts were the main environmental concern of marble manufacture. Dust was associated with raw handling material, plant maintenance, and water suspended materials by which emission sources were investigated to be derived from (i) court units, (ii) lawn mower, and (iii) polishers. Dust emission to the atmosphere from marble cutting process allocated at only one manufacture by which dust emissions had deteriorated the adjacent soils, plants, and surface water. Out of the eight manufacture plants, seven were implementing a wet medium cutting process.

Dusts have been found migrating and running in roads and side walks, accumulation of more than 5 cm above the soil surface knowing that Jordanian soils is already calcareous of pH around 8.2 restricting the availability of some nutrients for plant uptake. Dust may be arises from vehicle movements on unsealed roads and can also occur as a result of winds or storms or neighboring industries such as marble. The existing dust levels in the inspected sites are strongly affected by weather and particularly the strength of winds. Generated dust during operation may affect human, plant and animal growth at the surrounding community. Therefore, a management strategy should be implemented to avoid the negative impacts of dust contamination and to reduce the translocation of dust outside the plant, which can be achieved by plantation of wind-brake plants, sprinkling devices, collection of produced slurry from the cutting process directly to special tanks and entered into the slurry treatment process again.

4.9. Water Pollution

Effluent water quality of marble manufacture must fit the Industrial Wastewater Standard Specification (Jordanian Standard No.202 of 1991), in order to be reused for different purposes under the authority of Ministry of

Water and Irrigation. At the same time, reclaimed water are allowed to discharge or reuse when only its quality complies with the properties and defined quality standards in accordance to Reclaimed Domestic Wastewater Standard Specification, Jordanian Standard, No.893 of 2002 (Article (17) of the (EPL) number 12 of 1995). Disposing of treated wastewater can be achieved if and only if the treatment allows rendering or clearance from any environmentally detrimental substance according to Article (26) of the (EPL) number 12 of 1995. Effluent water samples were collected through a year of study and tested for chemical loads. Results indicated minor concentrations of Ca, Mg, K and SO_4 derived from marble itself, however, some samples showed high loads of Na (Table 5). The high sodium loads where derived from those manufactures adopting the wastewater treating units. Waste water treating process adopted by some manufactures were inspected to use a flocculating agent known as *PRAESTOL 2540 TR* (Stockhausen, 2003) to flocculate the colloidal Calcium Carbonate particles in the settling tanks. The coagulative chemical was inspected to be highly molecular of medium anionic polyelectrolyte copolymer of acryl amide and sodium acrylate. The compound was used in a diluted form of 0.05-0.1% by which it is environmentally friendly if used in such precise dilution range.

According to CER, the wastewater containing such chemical compound is classified as non-dangerous waste with code number (CER 01045), as their chemical type and concentration does not exceeds the permitted levels (2000 mg/kg), however, the direct contact to the chemical should be avoided especially the respiratory system and the direct eye contact if dust is produced. Toxicological information derived from the producing company (Stockhausen GmbH & Co. KG, Krefeld) based on knowledge of the properties of the components; adverse effects on human health are not to be expected in normal use. From the ecological standpoint, because of its specific substantively, the product can be eliminated well in biological waste effluent treatment plants (binding on digestive sludge).

The predictions of changes in water quality is evaluated based on the anticipated effluent discharges including the huge volume of discharge, the high concentration of suspended solids, and some concentration of harmful substances. Improving effluent quality and reducing effluent volumes to levels were taken into consideration, however, impact on the water resources will still a concern. Since waterborne effluent may reduce water quality with impacts on human health particularly where water is reused in some marble manufactories regardless of the inappropriate disposal strategies adopted, it is suggested to an alternative methodology by implementing an in-situ wastewater treatment plant to allow the disposal of their water into the sanitary drainage system or reuse it in irrigation non-edible trees or for cooling process if the chemical loads still within the allowed range.

4.10. Noise

Jordanian norms that control noise are not different from the European ones. The instructions for control and preventing noise of 1997 (Official Gazette, 1997) explains article 27 of the environmental protection Law number 12 of 1995 (Official Gazette, 1995) by which adopting the International Standards ISO- 2204-1979 (E), as well as the European regulations that determine the permitted noise level in the industrial areas to be less than 75/65 dB (A-scale).

Noise was monitored along the marble manufactures at Zarqa Governorate using (sound level meters and noise dosimeters) and over a number of 15-minute periods during a typical working day. Ideally, 4 or 5 periods was monitored at each sensitive receptor location. Results indicated background noise levels of 35 dB (A) and extent to 100 dB (A) during operation time. The measured noise level was on average of 100 dB (A) for eight continuous working hours per day which had exceed the allowed safe level. Therefore, it is highly recommended that new factories should be established at least 100 m away from the pedestrian area knowing that almost 6 dB sound level reduces for each 10 m.

As inspected at all marble production sites and surveyed by local community, noise resulting from traffic movement was much less than noise produced by cutting phase stage in marble production. Regardless that in both cases the noise level detected at the nearest residential area near marble manufactures did not reach 60 dB (A), however, noise in all case still disturbing people in residential areas of homes and schools.

According to the short negative sound impact, the existed establishments should implement noise safety plan. The safety plan should include noise abatement, machinery noise reduction via redesigning or replacement source receiver isolator. At the same time, internal employees should not be exposed to noise more than two hours especially within the first meter exposure to the noise source. Therefore, regular schedule work plan should be implemented for regular time change every two hours. The employer must develop a monitoring program for noise exposure through audiometric testing devices, while the employee, on the other hand, should use safety audiometric hearing protection device and should run a periodic otologic exam.

5. Conclusions

Marble production, as an industrial sector, has a great contribution to Jordanian gross national income due to both large Jordanian industrial capacity and marble reserve. However, there are some potential risk of such industry lying on the environmental, which requires attention, mitigations, and management to protect the existing human health and natural resources. From environmental point of view, results indicated that marble industry has few human impacts with minor environmental risks, however, each factory needs an intensive evaluation to determine the certain norms to regulate their action and to control the possible impact produced. However, new factories must be established within industrial zones to prevent environmental-community inflects and to allow better safe competition. On the other hand, existing factories have to introduce mitigation actions to minimize gradually the environmental impacts through providing

proper managements relevant to environmental performance test.

According to this study, the existed marble establishments violated the land use classification and municipality limits by being established on agricultural lands within pedestrian city limits away from industrial zones. According to site characteristics during and after work operations, marble production negatively and directly damaged the existing landform by intrusion of urban development and by loss of attractive features such as vegetation and hills. The major impact produced by marble manufacture is the direct negative social impact. Particulate dust is main environmental impact of marble production as inspected to be produced from marble cutting phase that requires implementation of wet medium cutting process to be legislated in marble manufactures. Dust impacts were obvious in deteriorating adjacent soils by accumulating more than 5 cm at the surface. However, dust emission requires a special management plan by plantation of wind-brake plants, sprinkling devices, collection of produced slurry from the cutting process directly to special tanks and entered into the slurry treatment process again. As inspected at all marble production sites and surveyed by local community, noise resulting from traffic movement was much less than noise produced by cutting phase stage in marble production. Regardless that in both cases the noise level detected at the nearest residential area near marble manufactures did not reach 60 dB (A), however, noise in all case still disturbing people in residential areas of homes and schools. Also, safety plan should be implemented including noise abatement, machinery noise reduction via redesigning or replacement source receiver isolator, regular employee schedule work plan, a monitoring program for noise exposure through audiometric testing devices, use of safety audiometric hearing protection device, and periodic employee otologic exam.

According to private and public traffic, the existence of marble infrastructure had anticipated in more traffic flow especially during operation with large diesel type vehicle, which moves according to establishment production to either 10 or more frequent moves a day. The presence of such vehicles requires safety issues for roads and driving controls. From economic standpoint, the marble production offers a positive impact and economic welfare of the local population by providing cash currencies and long-term benefits during operation and provides working opportunities. Waste products produced from marble manufacture were estimated to be around 10% of the prime material entered in processing. However, the difference between raw material consumption and production is not necessary assigned as waste products but rather could be byproducts since factories can sell flagstones as ornamental or construction units for garden landscaping, house floor flagstones and roads. The sources of the generated residues in marble manufacture can be categorized into (i) gravels and broken slabs, (ii) slurry and sludge, (iii) used oils and lubricants, and (iv) others. Disposal of solid waste as inspected, when inefficient, might lead to its accumulation affecting therefore the comfort and general health conditions of the local community. Thus, regulation actions should take more control in forcing the marble establishments to dispose their solid wastes in specialized industrial landfills outside the pedestrian areas.

The massive amount of water ranging from four to 48 m^3/day can be reused if treated properly in-situ by implementing chemical-stabilization wastewater treatment unit. If chemical treatment is implemented, then coagulated liquid sludge should be disposed into industrial treatment plants while cubed solid sludge can be disposed into landfills. According to site inspections, some manufactures violated the wastewater disposal strategy directing their effluents into the domestic sewage system. According to wastewater chemistry at the inspected factories, no chemicals other than the flocculating agent *PRAESTOL 2540 TR* were found with few minor impurities from the marble rock itself. The flocculating agent was used in marble process to flocculate the colloidal calcium carbonate particles in slurry. According to manufacture regulations, the coagulative chemical is highly molecular that is environmentally friendly which can be eliminated well in biological waste treatment plants where it is classified as non-dangerous waste with code number (CER 01045).

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