Soil Contamination in Hebron District Due to Stone Cutting Industry

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Abstract: Stone cutting industry is one of the major environmental pollutants in Palestine. The pollution process starts by mining rocks from quarries and transporting them to stone cutting plants distributed around the West Bank. The mining and transporting process is usually associated with different types of pollution such as air, noise and soil contamination. In stone cutting plants, rock blocks are cut into different sizes and shapes. The cutting and shaping process is accomplished by using metal saws which need a tremendous amount of cooling water. The cooling water is discharged out of the plant as highly viscous material referred to as stone slurry waste. The stone slurry waste poses a serious environmental hazard.

At present most of the stone slurry waste produced by the stone cutting industry, in the West Bank and Gaza Strip, is disposed of in agricultural land, open areas and sewage networks. This practice adversely affects the fertility of the soil, contaminates the ground, reduces ground water recharge and increases the drainage problem.

This study discusses the issue of soil contamination by stone slurry waste in Hebron district. It focuses on the effect of stone slurry waste on pH, Electrical Conductivity (EC), salinity and the Total Dissolved Solids (TDS) for three different types of soil (sand, Terra Rosa Clay and artificial organic soil).

The Global Positioning System (GPS) and the Geographic Information System (GIS) were used as a tool to estimate the total contaminated area in Hebron district. Spatial data and area maps were developed for the contaminated areas.

The results have revealed that the pH, EC, salinity and TDS of the artificial organic soil are significantly affected by the addition of different percentages of stone slurry waste up to 80%, compared to moderate and weak effect on Terra Rosa and sandy soils. Analysis of the spatial data from GPS and GIS has shown that the contaminated area in Hebron district varied between 0.73% and 20.6% of the total municipal area, assuming a buffer diameter of 100 meters for contaminated areas.

Keywords: Soil Contamination, Stone Cutting Industry, Stone Slurry Waste, pH, Electrical Conductivity, Salinity, Total Dissolved Solids.

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الملخص: تعتبر صناعة قص الحجر إحدى ملوثات البيئة الرئيسية في فلسطين. تبدأ عملية التلوث باستخراج الصخور من مقالع الحجر ونقلها إلى مناشير القص الموزعة في أنحاء مختلفة من الضفة الغربية. يصاحب عملية قص واستخراج الصخور من المقالع ونقلها إلى مناشير القص أنواع مـ ختلفة من التلوث البيئي، أهمها تلوث الهواء والتلوث الإزعاجي وتلوث التربة.

في مناشير الحجر يتم قص القطع الصخرية الكبيرة إلى قطع صغيرة بأحجام وأشكال مختلفة. وتتم عملية القص والتشكيل باستخدام مناشير معدنية يتم تبريدها بالماء أثناء عملية القص ينتج عن عملية القـ ص سائل عالي اللزوجة يتكون من ماء التبريد وفتات الصخر والعوالق والمكونات المعدنية الثقيلة والتي تسمى مادة ربو المحاجر . يتم التخلص من ربو المحاجر بشكل عشوائي في الأراضي الزراعية وفي شبكات الصرف الصحي وفي الوديان، مما يشكل مخاطر بيئية كبيرة في فلسطين . ومن أهم تلك المخاطر، تلوث التربة، وضعف خصوبة التربة الزراعية بسبب انسداد المسامات مما يؤثر على تسرب المياه إلى داخل التربة وعلى إعادة شحن آبار المياه الجوفية.

يركز هذا البحث على تلوث التربة نتيجة مادة ربو المحاجر في محافظة الخليل. وتركز الدراسة بشكل رئيسي على أثر تلك المخلفات على درجة الحموضة وخاصية التوصيل الكهربائية ودرجة الملوحة ونسبة المواد الصلبة الذائبة في التربة، وذلك في ثلاثة أنواع مختلفة من التربة (الرملية والطينية والتربة الزراعية العضوية الصناعية). كذلك تم استخدام نظام تحديد المواقع بالأقمار الصناعية (GPS) ونظم المعلومات الجغرافية (GIS) في جامعة بوليتكنك فلسطين) لتحديد مواقع جميع مقالع ومناشير قص الحجر في محافظة الخليل حسب نظام الإحداثيات الفلسطيني . بعد ذلك تم افتراض قطر 100 متر لمنطقة التلوث حول كل موقع، وبعد معالجة المعلومات في برامج نظم المعلومات الجغرافية (ArcView, ArcGIS)، أمكن تجهيز خرائط مساحية تم من خلالها حساب نسبة المساحات الملوثة بمادة ربو المحاجر من حدود أراضي بلدية الخليل والقرى التي توجد بها صناعة قص الحجر.

وقد أظهرت النتائج أن خاصية التوصيل الكهربائي ونسبة الحبيبات الصلبة الذائبة ونسبة الـ ملوحة قد تأثرت بشكل واضح في الحدود الزمنية للبحث في حين أن نسبة الحموضة لم تتأثر بشكل كبير . وقد كان الأثر واضحا جدا لتلك المتغيرات في التربة الزراعية العضوية الصناعية، في حين كان الأثر أقل وضوحا في التربة الرملية والتربة الطينية الطبيعيةكما بينت نتائج الـ تحليل باستخدام نظام تحديد المواقع بالأقمار الصناعية ونظم المعلومات الجغرافية أن نسبة مساحة الأراضي الملوثة بمادة ربو المحاجر في محافظة الخليل تتراوح بين 0.73% و20.6%.

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Introduction

Soil contamination is defined as the build-up in soils of persistent toxic compounds, chemicals, heavy metals, salts, radioactive materials, or disease causing agents, which have adverse effects on plant growth, human and animal health.[1] The soil may be considered contaminated when it contains a sufficient quantity of toxic or otherwise harmful material to pose threat to the health and safety of users of the land or workers engaged in its development. The integrity of buildings and plants may also be at risk. Soil contamination and land contamination are used alternatively. The major source of soil contamination in the West Bank and Gaza Strip are quarries and stone cutting plants.

1- Stone Quarries

Quarries represent the largest industry in the West Bank. The rocks nearby the Dead Sea are considered one of the natural resources in Palestine used in the field of construction and for other purposes, in Palestine and abroad. Over the last 40 years, Israel developed 6 quarries and originated many others, most of which are adjacent to the residential areas and agricultural lands. These quarries cause harmful effects to the environment because of the disposal of solid and liquid wastes. These quarries emit heavy dusts that are detrimental to the public health. The following table shows the first quarries in the West Bank established nearby the populated Palestinian territories:

Table 1: The early quarries established by Israel in the West Bank

No.	Quarries	Governorate	Notes
1	Quarry in Al-Zahiryya	Hebron	All these quarries exist near the populated areas, consequently causing the following harms: 1. Noisy explosions. 2. Heavy emission of dust. 3. Serious disturbance due to the continuous process of transportation.
2	Quarry in Dura	Hebron	
3	Quarry nearby Al-Dihaisha	Bethlehem	
4	Quarry in Ya'bid	Jenin	
5	Quarry nearby Giyos	Qalqilya	
6	Tzufim Quarry near Qalqilya	Qalqilya	

Currently, and according to the union of stone and marble industry,[2] the sources of stone are the some of 247-280 quarries situated across the West Bank. The work performed by quarries is the production of stones in different sizes and textures for use in construction. The vast majority of quarries are concentrated in the Hebron area, which is known for using the most modern and sophisticated machinery for extracting stone. It also has the reputation of producing stone with minimal defects, a good color and uniform texture.

2- Stone-Cutting Facilities and Workshops

There are approximately 600 stone-cutting facilities and workshops in the West Bank and Gaza.[2] Stone cutting establishments are spread across several areas of the West Bank. Major suppliers of stone are Bethlehem and Hebron, with other concentrations found in the northern districts of Jenin, Tulkarem and Nablus.

At present there are more than 470 facilities in the West Bank that utilize about 0.5 million m^3 of freshwater per year and generate nearly about 700,000 tons of slurry. Stone slurry waste contains heavy metals and suspension solids varying within the range of 5000 to 12000 mg/l, mainly consisting of calcium carbonate

(CaCo3).[3] The calcareous waste generated by quarrying and stone cutting industry has accumulated over years. Only insignificant quantities have been utilized and the rest has been dumped unscrupulously in open land, valleys and sewage systems, resulting in environmental and health problems.

Problem Definition

The environmental impact of stone slurry waste generated from quarries and stone cutting industry is extensive. The major impact is on air quality, surface and ground water, on flora and fauna due to contamination of agricultural soil. Calcium carbonate from stone slurry accumulated in the ditches and on the soil surface, resulting in the formation of lime cemented hard pans that restrict infiltration of water and root penetration into the soil layer. Stone slurry waste reduces soil fertility due to changes of the pH-value, EC, salinity and total dissolved solids (TDS). Fine dust or powder from dried slurry is blown away by the wind and can cover the surface of plants over a wide area for the whole summer due to the absence of rain. Recycled water of poor quality can cause diseases to workers mainly of the lungs and injuries to eyes from wind-blown stone powder. Stone slurry waste dumped in sewerage systems creates blockages and damages pumping stations. Figure (1) illustrates the stone slurry waste dumped on the top of the hill and flows to its final destination in agricultural lands.

Figure 1: Stone slurry waste flows from dumping site to the agricultural land.

Objectives and Importance of the Study

This study aims to investigate the problem of soil contamination due to stone cutting industry in Hebron district. The study further aims to:

- find out the effect of stone slurry waste on pH, EC, salinity and TDS of clayey (Terra Rosa) soil, organic artificial soil, and sandy soil, and
- develop spatial data and maps for the expected contaminated soil in Hebron district by using GPS and GIS.

This study is important for municipalities, ministries of agriculture and planning, and the authority of environmental quality. The spatial data and maps developed in this study are extremely important for future feasibility studies to establish a central treatment unit for stone slurry waste in Hebron district. Several studies pointed out to the problems caused by stone slurry waste to the environment in general; however, none of these studies investigated the problem of soil contamination due to stone slurry waste.

Literature Review

The chemical and mineralogical characteristics of stone slurry waste have been investigated in Italy,[4] which were found to vary with the type of original rocks and the composition of cutting saws. Some of these results are reproduced in Table (2) for two samples collected from two out of eleven firms covered by the study. The engineering properties of stone slurry waste were investigated in earlier research articles by the author at PPU,[5,6] the results of which revealing that stone slurry waste is a type of soil having properties between clay and sand soils. The natural moisture content of stone slurry waste was found to be 63%. It is non-plastic but having cohesion value about 0.08 kg/cm^2 and angle of internal friction of 35^o. The specific gravity of dry powder particles of stone slurry waste was reported as 2.46; the maximum wet and dry densities achieved were 1.73 and 1.6 gm/cm^3, respectively. The AASHTO and Unified classification groups of stone slurry waste were found to be A-2-6 (0) and SM, respectively. Several other studies were published about the potential use of stone slurry waste in the construction field and in the industrial field, especially those requiring calcium carbonate and lime.[7,8,9,10,11] In other studies, the effect of using limited percentages of stone slurry waste on plant growth has been investigated.[12,13] It should be noted that all properties of stone slurry waste are largely dependent on the type of rocks originated from the process of cutting, the metal material of the cutting saw, and the chemical additives used with cooling water.

The pH of soil, or more precisely the pH of soil solution, is very important because soil solution carries in it nutrients such as Nitrogen (N), Potassium (K), and Phosphorus (P) that plants need in specific amounts to grow, thrive and fight off diseases. If the pH of soil solution is increased above 5.5, Nitrogen (in the form of nitrate) is made available to plants. Phosphorus, on the other hand, is available to plants when the soil pH is between 6.0 and 7.0.

If the soil solution is too acidic, plants cannot utilize N, P, K and other nutrients they need. In acidic soils plants are more likely to take up toxic metals, and some plants eventually die of toxicity (poisoning).[14] The soil pH can also influence plant growth by its effect on the activity of beneficial micro-organism bacteria that decompose soil organic matter, and which are hindered in strong acid soils. This prevents organic matter from breaking down, resulting in the accumulation of organic matter and the tie up of nutrients, particularly nitrogen, that are held in the organic matter. Soils tend to become acidic as a result of: (1) rainwater leaching away basic ions (calcium, magnesium, potassium and sodium); (2) carbon dioxide from decomposing organic matter and root respiration dissolving in soil water to form a weak organic acid; and (3) formation of strong organic and inorganic acids, such as nitric and sulfuric acid, from decaying organic matter and oxidation of ammonium and sulfur fertilizers. Strongly acid soils are usually the result of the action of these strong organic and inorganic acids. Lime is usually added to acid soils to increase soil pH. The addition of lime not only neutralizes hydrogen ions and raises soil pH, thereby eliminating most major problems associated with acid soils, but it also provides two nutrients, calcium and magnesium to the soil. Lime also makes phosphorus, which is added to the soil, more available for plant growth and increases the availability of nitrogen by hastening the decomposition of organic matter. Liming materials are relatively inexpensive, and comparatively mild, to handle and leave no objectionable residues in the soil.[15]

Electrical conductivity (EC) is defined as the ability of a material to conduct current. Positive and negative ions in a solution will move to the oppositely charged electrode when an electric charge is applied to the solution, thus conducting current. EC of soil is influenced by interactions among the following soil properties: (1) Pore continuity, soils with water-filled pore spaces that are connected directly with neighboring soil pores tend to conduct electricity more readily. Soils with high clay content usually conduct electricity better than sandy soils. (2) Water content, dry soils are much lower in conductivity than moist soils. (3) Salinity level, increasing concentration of electrolytes (salts) in soil water will dramatically increase soil EC. (4) Cation exchange capacity, mineral soils containing high levels of clay minerals have a much higher ability to retain positively charged ions such as Ca, Mg, potassium (K), sodium (Na), ammonium (NH4), or hydrogen (H) than soils lacking these constituents. The presence of these ions in the moisture-filled soil pores will enhance soil EC in the same way that salinity does. (5) Depth, the signal strength of EC of soil decreases with depth. (6) Temperature, as temperature decreases toward the freezing point of water, soil EC decreases slightly. Below freezing, soil pores become increasingly insulated from each other and overall soil EC declines rapidly.[16]

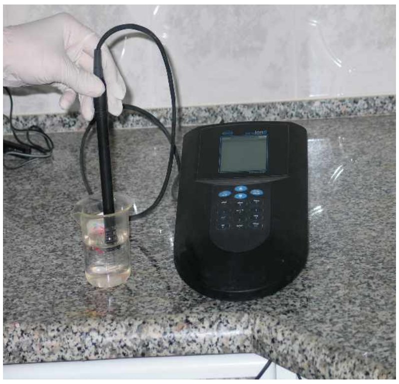
Salinity, a measure of the mass of dissolved salts in a given mass of solution, is used to describe sea water, natural and industrial waters. Salinity is a relative scale based on a KCl solution. A salinity value of 35 is equivalent to a KCl solution containing 32.4356 g KCl in 1 kg of solution at 15%. Salinity is measured in percentage.[17]

Table 2: Properties of Stone Slurry Waste [4]

Chemicals	**Sample 1** (Max-Min),%	**Sample 2** (Max-Min),%	**Minerals**	**Sample 1** (Max-Min), ppm	**Sample 2** (Max-Min), ppm
SiO2	71.19-33.99	62.55-55.42	Ba	1144.7-392	822-428.6
Al2O3	17.09-8.17	15.31-12.21	Rb	239.8-66.9	182-74.3
Fe2O3	5.09-1.84	15.12-7.4	Sr	361.9-66.9	465.8-232.4
MgO	11.44-0.7	2.74-1.24	Mo	3.9-0.1	36.3-10.5
CaO	16.77-1.79	7.23-3.37	Cr*	41.1-0.7	417.4-54.7
Na2O	4.13-1.74	3.8-2.83	Ni*	29.2-1.9	130.6-37.2
K2O	4.12-1.74	3.68-2.37	Co*	245-54.3	33.3-9.7
TiO2	0.76-0.21	0.58-0.27	Cu*	163.4-14.4	233.1-67.8
P2O5	0.5-0.07	0.23-0.12	As*	1.4-0.5	11.5-2
MnO	0.12-0.04	0.16-0.09	Pb*	91.1-1.4	6.5-1.4
LOI	20.1-0.65	1.55-0.48	Zn*	788-50	72-37
			V*	75-17	68-33
			W	34.8-0.4	13.7-0.9

Methodology

Samples were prepared by mixing up specific percentages of stone slurry waste as powder by the three types of soil under investigation. The percentages of stone slurry waste varied from 20% to 80%. Aqueous solution was then prepared from each soil sample by mixing 60 gm of soil with 100 ml of distilled water. The values of pH, EC salinity and TDS were measured by using special instruments after calibrating them as in the instruction manuals.[18,17] Figure (2) shows the instruments used in the laboratory for measuring pH, conductivity, salinity and TDS. A questionnaire was prepared for data collection about stone quarries and stone cutting plants in Hebron district. The questionnaire contained information about the establishment and its stone production and activities in addition to its local coordinate systems which were recorded by using GPS tools.



(A)

(B)

Figure 2: (A) pH meter; (B) Conductivity, Salinity and TDS meter

Experimental Test Results

1. PH, EC, Salinity and TDS Tests Results:

Table (3) presents the experimental test results of the four tests for the three types of soils. The tests were carried out after 15 days of sample preparation. The results showed that pH does not change significantly during the time frame of this study. This may be attributed to the low solubility of stone slurry waste in water ($CaCO3$). More pronounced effects on pH may occur after considerable time of sample preparation. Variation of pH with stone slurry waste for the three types of soil is shown on Figure (3). Variation of EC with stone slurry waste is shown in Figure (4). For Terra Rosa soil the conductivity has dropped from 843 (μ.s/cm) to 580 (μ.s/cm). However, the conductivity of sand has increased from 445 (μ.s/cm) to 548 (μ.s/cm). For organic soil, the value of EC dropped from 11.21 (μ.s/cm) to 4.11(μ.s/cm).

Variation of salinity with stone slurry waste is shown in Figure (5). For Terra Rosa soil and sandy soil, salinity almost remains constant around 0.4% and 0.2%, respectively. For organic artificial soil, salinity has dropped from 6.4% to 2.2% by the addition of 80% stone slurry waste. Variation of TDS with stone slurry waste is shown in Figure (6). It is noticed that TDS for Terra Rosa soil and organic soil were dropped by considerable values, while they slightly changed for sandy soil.

Table 3: Effect of Stone Slurry Waste on pH, EC, Salinity and TDS

Type of Soil + Stone Slurry Waste (%)	**pH**	**Conductivity (μ.s/cm)**	**Salinity (%)**	**TDS (mg/l)**
Terra Rosa + 0.0 %	6.72	843	0.4	412
Terra Rosa + 20 %	6.67	737	0.4	359
Terra Rosa +40 %	6.58	678	0.3	330
Terra Rosa +60 %	6.64	609	0.3	296
Terra Rosa +80 %	6.63	580	0.3	281
	pH	**(μ.s/cm)**	**(%)**	**(g/l)**
Organic Soil + 0.0 %	5.41	11.21	6.4	6.16
Organic Soil + 20 %	5.54	9.76	5.5	5.31
Organic Soil + 40 %	5.76	7.84	4.4	4.2
Organic Soil + 60 %	5.85	6.35	3.5	3.35
Organic Soil + 80 %	6.07	4.11	2.2	2.14
		(μ.s/cm)	**(%)**	**(mg/l)**
Sand + 0.0 %	7.26	445	0.2	215
Sand + 20 %	6.99	422	0.2	204
Sand + 40 %	6.95	494	0.2	239
Sand + 60%	6.94	507	0.2	246
Sand + 80%	6.86	548	0.3	266
		(μ.s/cm)	**(%)**	**(mg/l)**
Stone Slurry Waste only	6.80	509	0.2	246

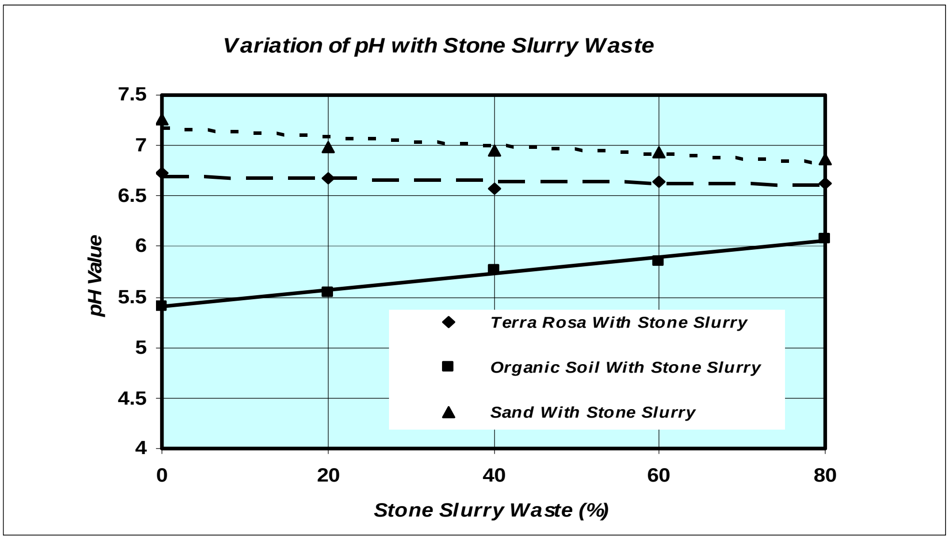


Figure 3: Variation of pH with stone slurry waste

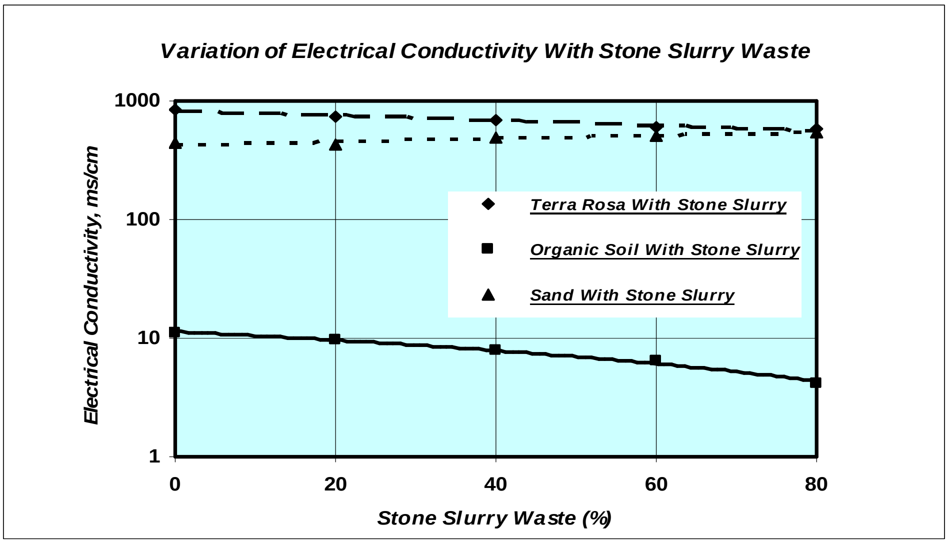


Figure 4: Variation of EC with stone slurry waste

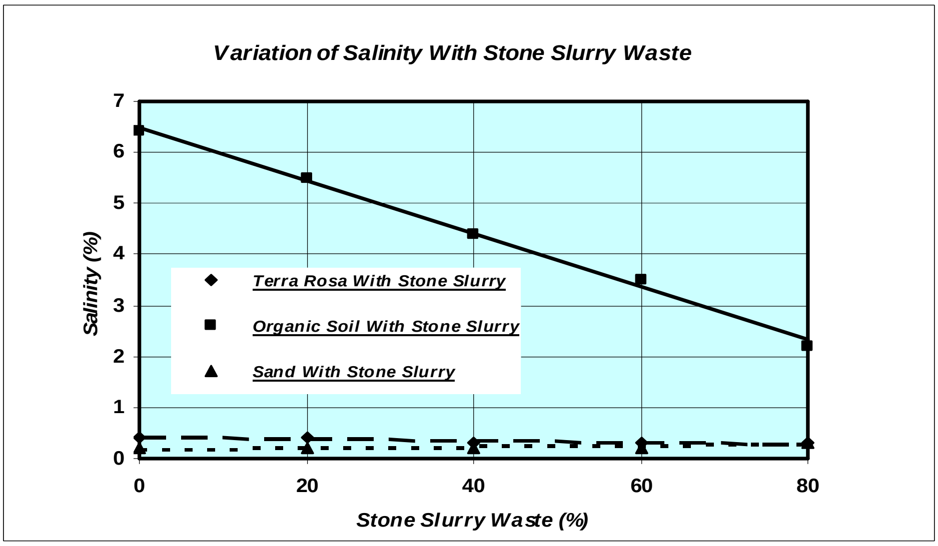


Figure 5: Variation of salinity with stone slurry waste

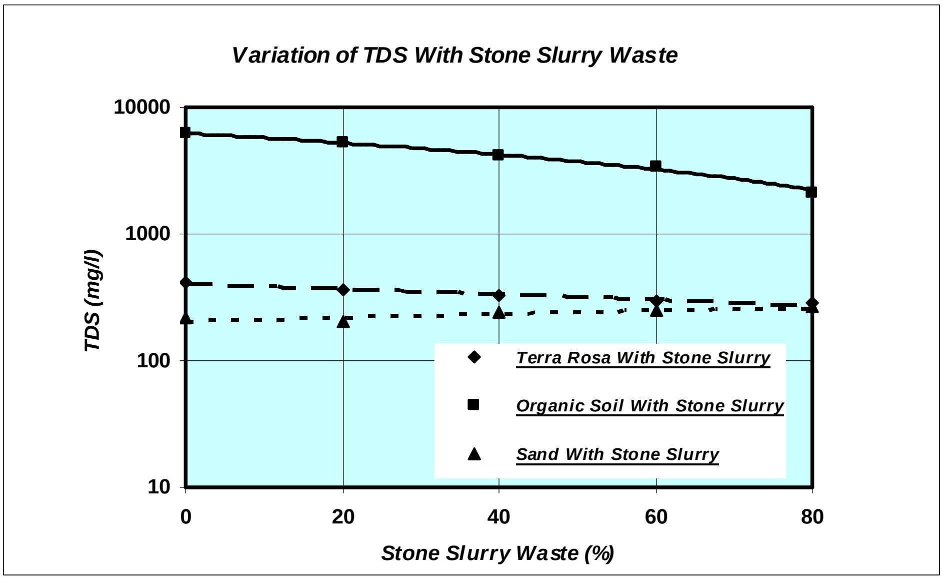


Figure 6: Variation of TDS with stone slurry waste

It should be noted that the effect of stone slurry waste on permeability of clayey and sandy soils was investigated in earlier research by the author.[6] It was found that the permeability coefficient has decreased about 92% and 46% for clay and sand, respectively, upon the addition of 3% of stone slurry waste by weight.

2. Spatial Data and Map for Stone Cutting Plants in Hebron District:

Table (4) illustrates the coordinate points of 70 stone cutting plants in Hebron city, which were covered in the field survey. Figure (7) illustrates the spatial map developed for quarries and stone cutting plants in Hebron city (Alfahs area). The map was developed from the data collected by field survey with structured questionnaire. The coordinate points of each stone cutting plant were recorded by using Magellan GPS instrument. Analysis of the spatial map indicated that 105,239,4 m^2 of Hebron city is contaminated. The total municipal area of Hebron city was computed from aerial maps of the city, and found to be 43,000,000 m^2. The contaminated area was then compared with municipal area, and it was found that 2.45% of Hebron municipal area is contaminated with stone slurry waste. These results will definitely be helpful and valuable for decision makers.

Table 4: Local coordinate points of stone cutting plants in Hebron city

No.	X, (m)	Y, (m)		No.	X, (m)	Y, (m)		No.	X, (m)	Y, (m)
1	160362	101832		24	160605	101529		47	159987	101885
2	160326	101576		25	160572	101501		48	160335	101366
3	160340	101634		26	160690	101787		49	160357	101364
4	160063	102101		27	160676	101669		50	161400	101360
5	160151	102263		28	160712	101636		51	161404	101354
6	160157	101204		29	160708	101532		52	161498	101400
7	160211	101982		30	160766	101558		53	161513	101457
8	160227	101871		31	160809	101535		54	161392	101418
9	160171	101866		32	160802	101557		55	161328	101509
10	160135	102270		33	160783	101739		56	161361	101615
11	160146	102305		34	160853	101784		57	161276	101645
12	160300	101610		35	160827	101992		58	161415	101713
13	160475	101900		36	160727	101971		59	161378	101719
14	160347	102024		37	160892	102051		60	161253	101838
15	160427	101927		38	160925	102291		61	161290	101857
16	160320	102020		39	160960	101559		62	161324	101875
17	160294	102105		40	160937	101436		63	161320	101920
18	160221	102169		41	161157	101362		64	161387	101953
19	160933	102199		42	161157	101322		65	161378	101871
20	160132	102344		43	161223	101638		66	160454	101634
21	160484	101958		44	161230	101684		67	157862	102243
22	160640	101700		45	159404	104099		68	160282	101773
23	160585	101560		46	159947	101898		69	160756	101732
								70	160887	101848

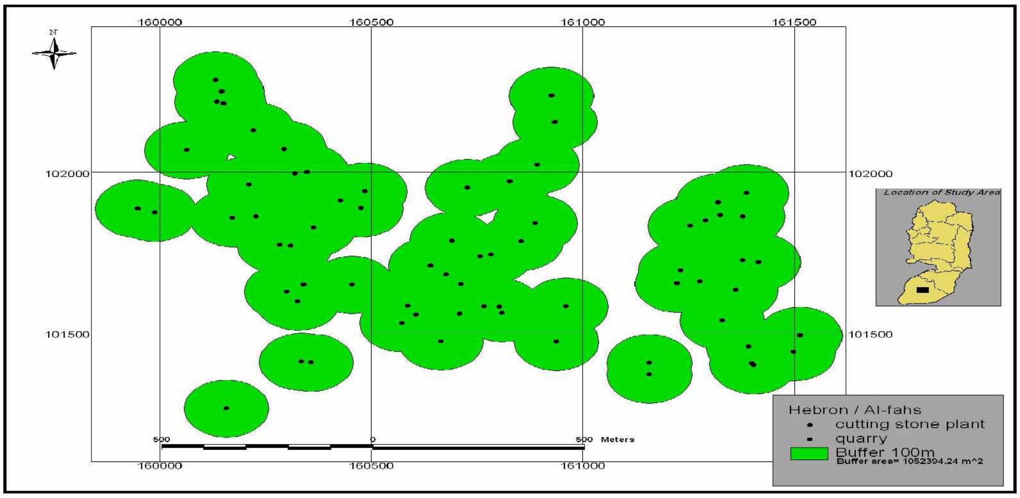


Figure 7: The expected contaminated soil area in Hebron/Al-fahs

Similar data, as shown in Table (4), were collected for all towns and villages in Hebron district, where stone cutting industry is available. Spatial area maps are developed for each town in the same way as in Figure (7). The results are illustrated in Figures (8 to 14).

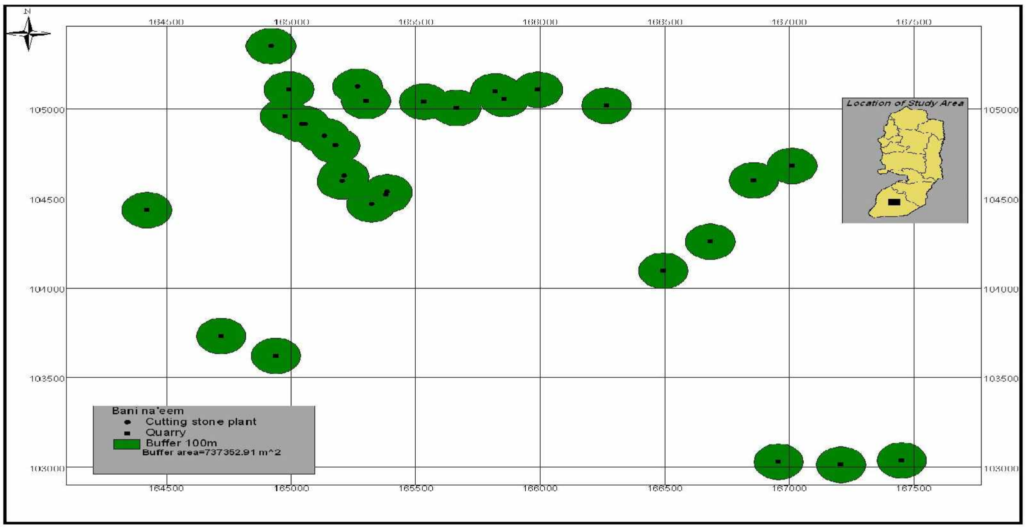


Figure 8: The expected contaminated soil area in Bani Na'eem Village

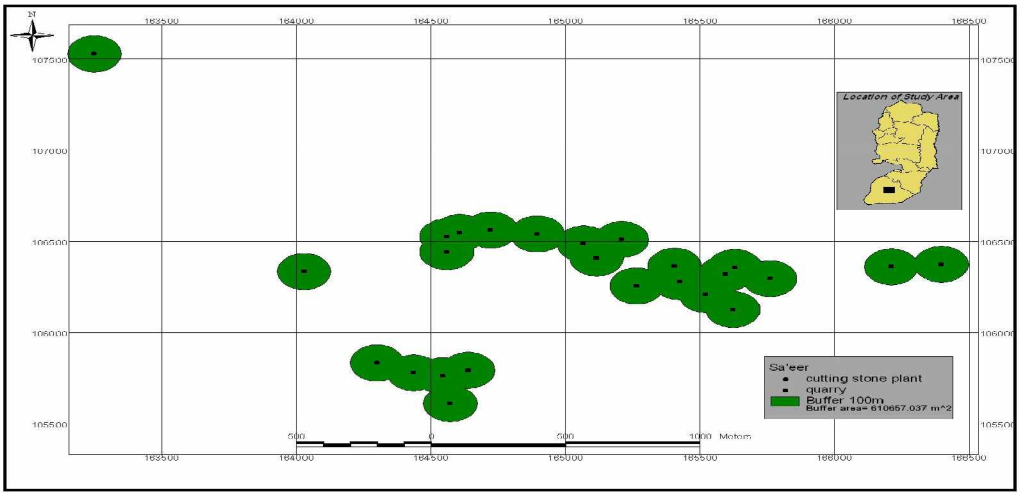


Figure 9: The expected contaminated soil area in Sa'eer Village

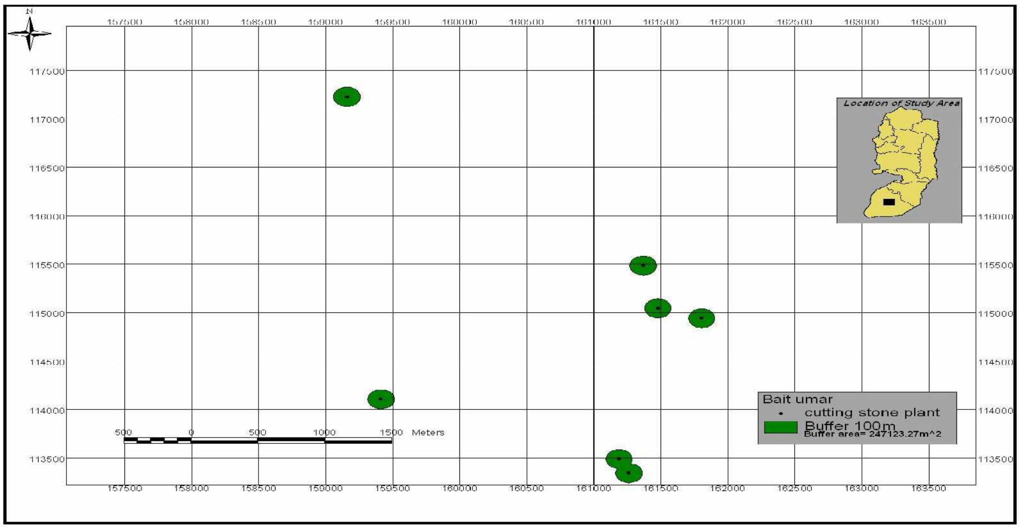


Figure 10: The expected contaminated soil area in Bait Umar Village

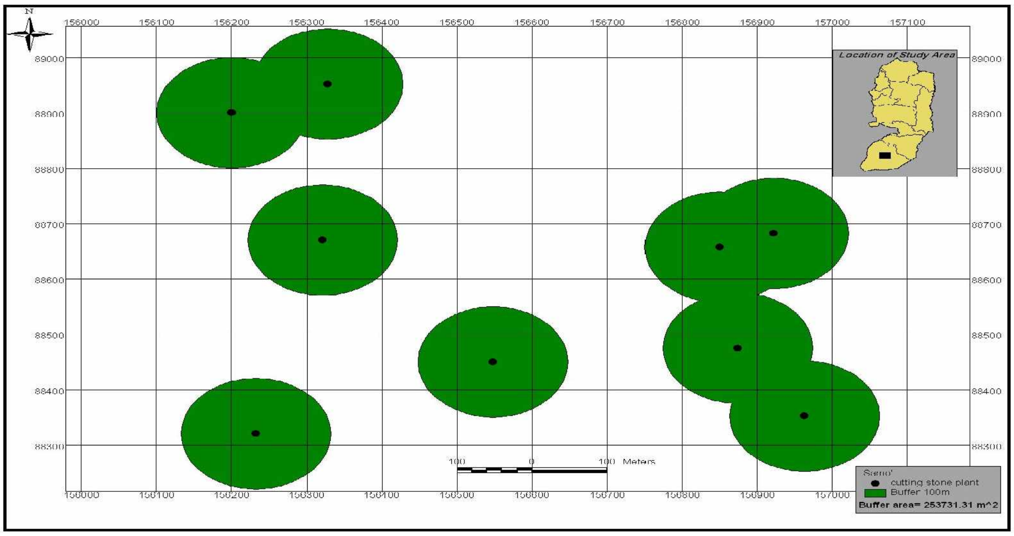


Figure 11: The expected contaminated soil area in Samou' Village

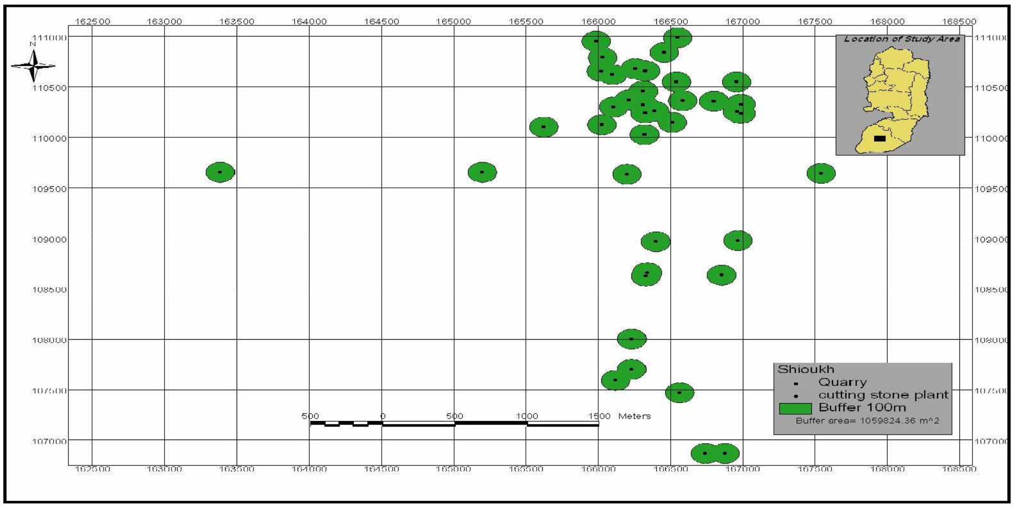


Figure 12: The expected contaminated soil area in Shioukh Village

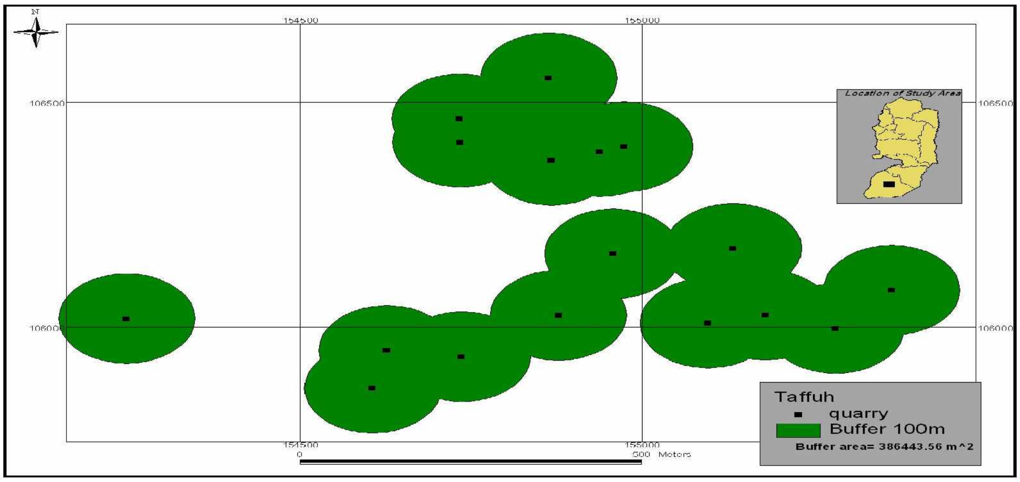


Figure 13: The expected contaminated soil area in Taffuh Village

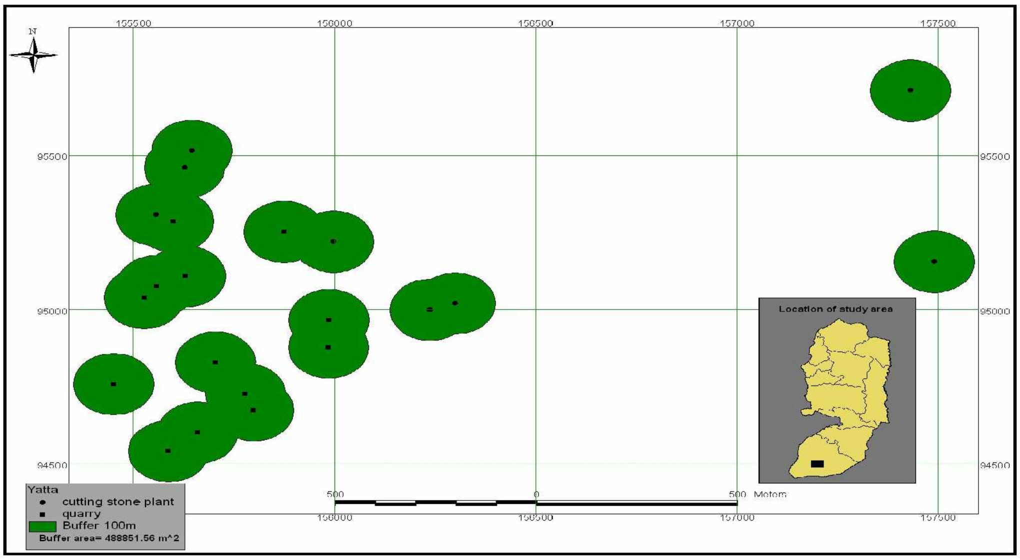


Figure 14: The expected contaminated soil area in Yatta Village

Table (5) summarizes the expected contaminated soil area in Hebron district according to the spatial data and maps developed by GPS and GIS, and based on the assumption of a 100 m diameter buffer zone.

Table 5: Estimated contaminated area in Hebron District

Name of City/Village	Total Municipal Area (m^2)	Contaminated Area (m^2)	Contamination (%)
Hebron/Al fahs	43,000,000	1052394.242	2.45
Samo'	27,000,000	253731.315	0.94
Beit Uummar	34,000,000	247123.271	0.73
Bani Na'eem	25,000,000	215866.599	0.86
Sa'eer	17,000,000	610657.037	3.60
Shioukh	5,140,000	1059824.364	20.6
Tafuh	22,000,000	386443.56	1.76
Yatta	24,552,265	488851.856	1.99

Summary and Conclusions

In this research, an attempt was made to investigate the problem of soil contamination due to stone slurry waste in Hebron district. Several tests were carried out, which are indicators of soil quality. The tests included pH, EC, Salinity and TDS. A survey was carried out in Hebron district for all quarries and stone cutting plants, aiming at gathering data and information about the type of plant, size, local coordinate points, amount of fresh water consumed and stone slurry waste generated per month. The coordinate points were found by using Magellan GPS instrument. The geographic information system available in the PPU was utilized to establish spatial map for the expected contaminated areas. The spatial map was developed based on the assumed buffer zone diameter of 100 meter. From the test results the following points may be concluded:

1- The effect of stone slurry waste on pH is not significant in the time frame of this study. The pH values dropped about 0.1 for clayey soil and 0.4 for sandy soil, whereas it increased by 0.6 for organic soil. This may be attributed to the low solubility of calcium carbonates in water.
2- EC of clayey soil decreased by 31% (from 843 µ.s/cm to 580 µ.s/cm) in 15 days after the mixing of soil samples with stone slurry waste, and for sandy soil it has increased by 23% (from 445 µ.s/cm to 548 µ.s/cm) under the same conditions, as for clay soils. However, for organic soil EC dropped by 63% (from 11.21 µ.s/cm to 4.11µ.s/cm).
3- Salinity of clayey and sandy soils remained almost unchanged, where it dropped from 6.4% to 2.2%.
4- TDS for clayey and sandy soils changed slightly in (mg/l units), where TDS for organic soils dropped from 6.16 g/l to 2.14 g/l.
5- Spatial maps were prepared for Hebron city and towns where stone cutting industry is available. The maps were produced by utilizing the GPS and GIS tools. Spatial analysis indicated that the contaminated area varied from 0.73% to 20.6%. In Hebron city, 2.45% of the municipal area is contaminated by stone slurry waste.

Recommendations

1- The pH, EC Salinity and TDS tests were conducted after 15 days of sample preparation. Further studies should investigate the effect of time on these properties with the presence of the contaminant (stone slurry waste).
2- There is high potential to use amounts of stone slurry waste as powder in the production of artificial organic soils with specific properties.
3- The effect of stone slurry waste (%) on plants growing should be investigated.
4- Preparation of spatial data and maps for contaminated soil in the West Band and Gaza will contribute towards better understanding and management of stone slurry waste.

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