Flour Mils Characterization Governorate of Qalyoubia

Livelihood and Income from the Environment Program
Lead Pollution Clean-up in Qalyoubia

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ACRONYMS

CI	Chemonics International
CEHM	Center for Environmental Hazard Mitigation, Cairo University
EEAA	Egyptian Environmental Affairs Agency
GOE	Government of Egypt
GOQ	Governorate of Qalyoubia
LIFE	Livelihood and Income from the Environment Program
MSE	Millennium Science & Engineering, Inc.
QA/QC	Quality Assurance and Quality Control
PRG	Preliminary Remediation Goal
RPD	Relative Percent Difference
SAP	Sampling and Analysis Plan
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
XRF	X-Ray Fluorescence

SYMBOLS FOR METALS

As	Arsenic
Cd	Cadmium
Hg	Mercury
Pb	Lead

UNITS OF MEASUREMENT

m	meter
m^2	square meter
$\mu g/ft^2$	microgram per square foot
mg/kg	milligram per kilogram (parts per million)
µm	micrometer (micron)

EXECUTIVE SUMMARY

Two families in the village of Abou El Gheit in the Kanater El Khyria District of the Governorate of Qalyoubia (GOQ), Egypt, were reported to have been poisoned by lead in November 2006. An investigation conducted by the Ministry of Health and Population and the Egyptian Environmental Affairs Agency confirmed that the acute poisonings was due to lead, but did not determine the exact source. One suspected source of poisoning was two flour mills which were used by both families to grind their grain.

Following the poisoning of the two families, the Governor of Qalyoubia requested the USAID-funded LIFE-Lead Pollution Cleanup in Qalyoubia Project (LIFE-Lead) to conduct a study aimed at characterizing the level and potential sources of heavy metal contamination in flour from the mills located in the GOQ. Twenty (20) flour mills, distributed amongst the various districts of the GOQ, were randomly selected for sampling and analysis. The characterization included soil and water sampling as well as wipe samples of the vegetation from seven agricultural fields to further assess other possible sources of heavy metal contamination. Sampling activities commenced on May 28, 2007 and continued through July 3, 2007. Sampling activities involved the collection of the following samples:

- 204 grain, flour, additives, dust, and wipes sample from flour mills.
- 146 soil, wipe, and water samples from the agricultural fields.

All collected samples were transported by LIFE-Lead to the Cairo University Center for Environmental Hazard Mitigation (CEHM) laboratory for analysis of lead, cadmium, arsenic, and mercury. Analysis results for food samples (i.e., grain, flour, and additives) were compared to the maximum levels for heavy metal contaminants in grain and flour specified in the Egyptian Standard No. 2360-1993. Dust, soil, and wipe samples were compared to the proposed USEPA Region 9 Preliminary Remediation Goals (PRG's) for chemicals in residential areas.

An evaluation of analysis results revealed the following:

- Arsenic and mercury were not detected in any of the analyzed samples.

- Cadmium was detected in 13% of the analyzed samples (10 samples), none of which with concentrations exceeding the Egyptian standard limit of 0.1 mg/kg.

- Lead was detected in 57% of the analyzed samples (40 samples) of which 11% (8 samples) exceeded the limits specified in the Egyptian standard.

- Lead was the only contaminant that exceeded the Egyptian standards in 17 percent of flour (corn and wheat) samples.

- Lead concentrations increased during the grinding process (i.e., the grain entering the mill to be ground had a lower lead content than the flour following processing).

- Concentrations of heavy metals in the agricultural field samples (soil, wipe, and water) were below PRGs.

Based on the above evaluation, the following conclusions are made:

- Lead is considered the contaminant of concern (COC) in food samples.
- The potential for crop contamination is unlikely to occur during the cultivation phase.
- The grinding process is a potential source of lead contamination in flour.

Due to the above conclusions, one of the flour mills suspected of causing the acute lead poisoning in the village of Abou El Gheit was revisited in July 2007 to attempt to identify the source of lead contamination in the grinding machine. During this visit, samples were collected from metallic components of the machine and analyzed using an XRF. In addition, chips from the grinding stone were obtained and analyzed at the CEHM laboratory. Analytical results revealed that lead was detected in all samples collected from components of the grinding machine. It is believed that excessive wear and tear of these components during grinding could contribute to lead contamination in the flour.

A preliminary Human Health Risk Evaluation was performed using the analytical results of flour and grain samples. This evaluation showed that the percentage of children who will have a blood lead level (BLL) above 10 µg/dl is 72.7%, which is significantly above the USEPA standard of 5 percent.

Based of the characterization of the flour mills, the primary recommendations of this report include the following:

- Alternatives to the current grinding process should be investigated to produce flour with heavy metal contaminant levels less than the Egyptian standard.

- The health risk assessment presented in this report is considered preliminary as the number of samples is small and below the number typically used to conduct a health risk assessment. It is recommended that further random sampling over an extended period of time be performed to develop a more reliable health risk assessment. This sampling should be conducted by the Egyptian Environmental Affairs Agency Central Laboratory staff in coordination with the GOQ.

INTRODUCTION

Heavy metal contamination of food products, especially lead, poses serious health impacts on consumers. In November 2006, two families in the village of Abou El Gheit in the Kanater El Khyria District of the Governorate of Qalyoubia (GOQ), Egypt, were reported to have been poisoned by lead. The Ministry of Health and Population and the Egyptian Environmental Affairs Agency conducted an investigation to determine the source of the contamination and provided the results to the GOQ. The investigation confirmed that the acute poisonings was due to lead, but did not identify the exact source of the lead. One potential source was two flour mills used by both families to grind their grain and were considered the common link to the lead poisonings.

Following this investigation, the Governor of Qalyoubia requested that the LIFE-Lead Pollution Clean-up in Qalyoubia (LIFE-Lead) project sample the two flour mills in an attempt to determine the source of the lead and verify the results of its investigation. In December 2006, LIFE-Lead personnel conducted site visits to the two flour mills to collect initial samples. Dust, grain, flour, and soil samples were collected and analyzed using an X-Ray Fluorescence (XRF) device. Analysis results indicated the presence of lead in the flour. However, the results of the analysis suggested that further characterization of flour mills was needed to assess the concentrations of heavy metals in grain and flour and the potential source of lead.

LIFE-Lead is a lead clean-up component under the Livelihood and Income from the Environment Program (LIFE). LIFE-Lead was designed by the United States Agency for International Development (USAID) and the Government of Egypt (GOE) and is being implemented by Millennium Science & Engineering, Inc. (MSE), in association with Chemonics International (Chemonics). To date, the project has remediated seven secondary lead smelter sites, a copper smelter, two schools, and a medical center. In addition to site remediation activities, the project includes activities in community involvement and public participation, communications, capacity building, and policy/legal support.

LIFE-Lead was initiated on August 18, 2004 with a closing date of March 30, 2007. The project was extended from March 30, 2007 until December 31, 2007 and then from January 1, 2008 through April 30, 2008 to allow for the characterization of flour mills in Governorate of Qalyoubia (GOQ), additional remediation activities, and capacity building activities.

In early 2007, an inventory of the flour mills in GOQ was obtained from Ministry of Supplies. Based on this inventory, a total of approximately 200 mills were identified as operating within different areas of the governorate. Twenty (20) flour mills were randomly selected for further characterization such that the various districts of the GOQ were covered. The purpose of this characterization is to assess the source and potential for heavy metal contamination in flour by sampling from agricultural fields, irrigation water, and crops, as well as flour mills.

Field activities commenced on May 28, 2007 and continued through July 3, 2007. Field activities were conducted in accordance with the Sampling and Analysis Plan described later in this document. This document provides: (i) a description of site sampling and analysis activities; and (ii) site characterization findings of GOQ sampled mills and agricultural fields. These findings will be used in the preparation of a preliminary Baseline Human Health Risk Evaluation and the development of recommendations for improving the milling process and protecting public health.

LEGISLATIVE FRAMEWORK AND STANDARDS

Egyptian Standards

Maximum levels for heavy metal contaminants in grain and flour are specified in the Egyptian Standard No. 2360-1993. This standard specifies metals of concern and their corresponding maximum acceptable levels in parts per million (ppm) as indicated in Table1.

Table 1: Maximum Acceptable Levels of Heavy Metal Contamination in Food Specified in the Egyptian Standard

Heavy Metal of Concern	Lead (Pb)	Cadmium (Cd)	Arsenic (As)	Mercury (Hg)
Regulatory Limits	0.5 mg/kg (ppm)	0.1 mg/kg (ppm)	0.5 mg/kg (ppm)	0.5 mg/kg (ppm)

The limits of acceptable levels of heavy metals in water are specified in the Egyptian standard's Law 38/82 (Article 60). Limits of acceptable concentrations of heavy metals in soil are adopted by EEAA from the Canadian Environmental Quality Guidelines for agricultural soil. These standards specify metals of concern in soil and water and their corresponding maximum acceptable levels are specified as summarized in Table 2.

Table 2: Maximum Acceptable Levels of Lead in Soil and Water Specified in the Egyptian Standard

<table>
<tr><th colspan="2">Heavy Metal of Concern</th><th>Lead (Pb)</th></tr>
<tr><td rowspan="2">Regulatory Limits</td><td>Soil</td><td>70 mg/kg (ppm)</td></tr>
<tr><td>Water</td><td>0.05 mg/L (ppm)</td></tr>
</table>

Based on the above standards, chemical analysis of samples collected from selected flour mills and agricultural fields focused on the detection of heavy metals of potential concern (i.e., Pb, Cd, As, Hg).

International Standards

Maximum levels for contaminates in wheat and corn grain specified in the Egyptian standards are compared with those specified in the international standards for contaminants in food and feed commodity. These sources of the international standards include the following:

- *Codex[1] General Standard for Contaminants and Toxin in Foods, CODEX, STAN 193-1995, Rev2-2006.*
- *European Commission Regulation (EC) No. 1881/2006 of 19 December 2006, setting maximum levels for certain contaminants in foodstuffs.*

A comparison of maximum levels of contaminants in grain, as specified in the above standards, is presented in Table 3

[1] Codex Alimentarius Commission (CAC) Standards is the international food standards setting body of the United Nations, joint venture of the Food and Agricultural Organization of the United Nations (FAO) and the World Health Organization (WHO)

Table 3: Maximum Acceptable Levels of Heavy Metal Contamination in Food Specified in International Standards

Standard	Lead (Pb)	Cadmium (Cd)	Arsenic (As)	Mercury (Hg)
Codex General Standards	0.20 mg/kg(1)	0.10 mg/kg(2) 0.20 mg/kg(3)	--(4)	--(4)
EC Regulations	0.20 mg/kg(5)	0.10 mg/kg(2) 0.2 mg/kg(6)	--(4)	--(4)

Notes:
(1) For cereals except buckwheat, canihua, and quinoa.
(2) For cereals excluding wheat, rice, barn, and germ.
(3) For wheat.
(4) No data available for maximum levels of contaminants in grains.
(5) For cereals, legumes, and pulses.
(6) For barn, germ, wheat, and rice.

As shown in the above table, the Egyptian standards specify higher values for the maximum levels of heavy metal contaminants in food grain. This could be attributed to the fact that the Egyptian standard for metal contaminants in food was issued in 1993 and has not been updated since that time. While, recent revisions of above mentioned international standards were issued in 2006.

With regards to dust and wipe samples, they were collected to account for non-process related contamination (i.e., external source of contamination). Therefore, the levels of heavy metals detected in these samples do not abide by the limits of the Maximum Levels of Heavy Metal Contaminants in Food of the Egyptian Standard No. 2360-1993. However, the analytical results of dust and wipe samples were compared to the proposed United States Environmental Protection Agency (USEPA) Region 9 Preliminary Remediation Goals (PRG's) for chemicals in residential areas. The limits for comparison of dust and wipe sample analysis results is provided in Table 4.

Table 4: Limits of Heavy Metal Contamination in Dust and Wipe Samples Based on USEPA Region 9 Preliminary Remediation Goals

Parameter	Dust and Wipe Samples mg/kg (ppm)
Lead (Pb)	400
Cadmium (Cd)	37
Arsenic (As)	0.39
Mercury (Hg)	6.1

SAMPLING PROCEDURES

All samples were collected in accordance with the Sampling and Analysis Plan (SAP) developed for the characterization of the flour mills (LIFE-Lead, 2007). This plan was prepared in accordance with international standards and USEPA guidelines and protocols for dust, soil, wipe, and water sampling.

The purpose of this SAP was to provide guidance to the sampling team for the proper collection, storage, and analysis of the samples, and to establish quality assurance and quality control (QA/QC) procedures to be followed during the field activities. As part of this sampling process, grain, flour, bulk dust, and wipe sampling was conducted at the mills as well as soil, wipe, and water sampling in the agricultural fields.

Field work commenced on May 28, 2007 and was completed on July 3, 2007.

A brief description of the milling process is provided below. The milling process was used to determine the sampling procedures of the SAP.

Flour Mills – Process Description

A typical layout of a rural flour mill is illustrated in Figure 1. The flour mill typically comprises of an electric or diesel fuel powered millstone, flour sieve, and an engine compartment. Grinding of wheat and corn grain is performed using a pair of millstones manufactured from granite as shown in Figure 2. Specifically, the lower stationary millstone is known as the base or bedstone and an upper revolving millstone is known as the runner stone. The runner stone is supported by a cross-shaped metal mill rynd fixed to a "mace head" topping the main shaft or spindle leading to the driving mechanism of the mill which is either electrically or diesel fuel powered.

The grinding process takes place between the upper moving stone (i.e., runner stone) and the lower stationary granite stone (i.e., bedstone). The grinding process starts by pouring grain into an approximate one cubic meter hopper which feeds the grain between the grinding stones. After grinding, the flour is discharged through an outlet at the base of the grinder and collected in bags or buckets. Grains delivered to the flour mills include corn, wheat, or a mixed of corn and wheat grains.

Production rates at rural flour mills depend on the number of grain sacks delivered by local farmers; therefore, operation at the flour mills is considered a batch process. No detailed records of production rates exist for these flour mills.

Sampling Locations

An inventory of the flour mills in the GOQ was provided by the Ministry of Supplies. Based on this inventory, a total of approximately 200 mills were found to be operating within different areas administrative districts of the governorate (Figure 3). Twenty (20) flour mills were randomly selected for further investigation such that the various districts of the GOQ are encompassed in the investigation (Figure 4).

The list of mills sampled including the location of each mill within the GOQ, the date of sampling, and the corresponding mill layout figure number are provided in Table 5. For each mill, site characterization activities included the collection of representative wheat/corn grain, flour, dust, and wipe samples from within the mill.

Efforts were made to collect the majority of the dust and wipe samples from the mill components to allow for a more comprehensive evaluation of the milling process. The components investigated included; feeding hoppers, sieving equipment, grinding stones, and the flour outlet nozzle. Additionally, dust and wipe samples were also collected from walls, building corners, scales, and old equipment.

Figure 1: Typical Flour Mill Layout

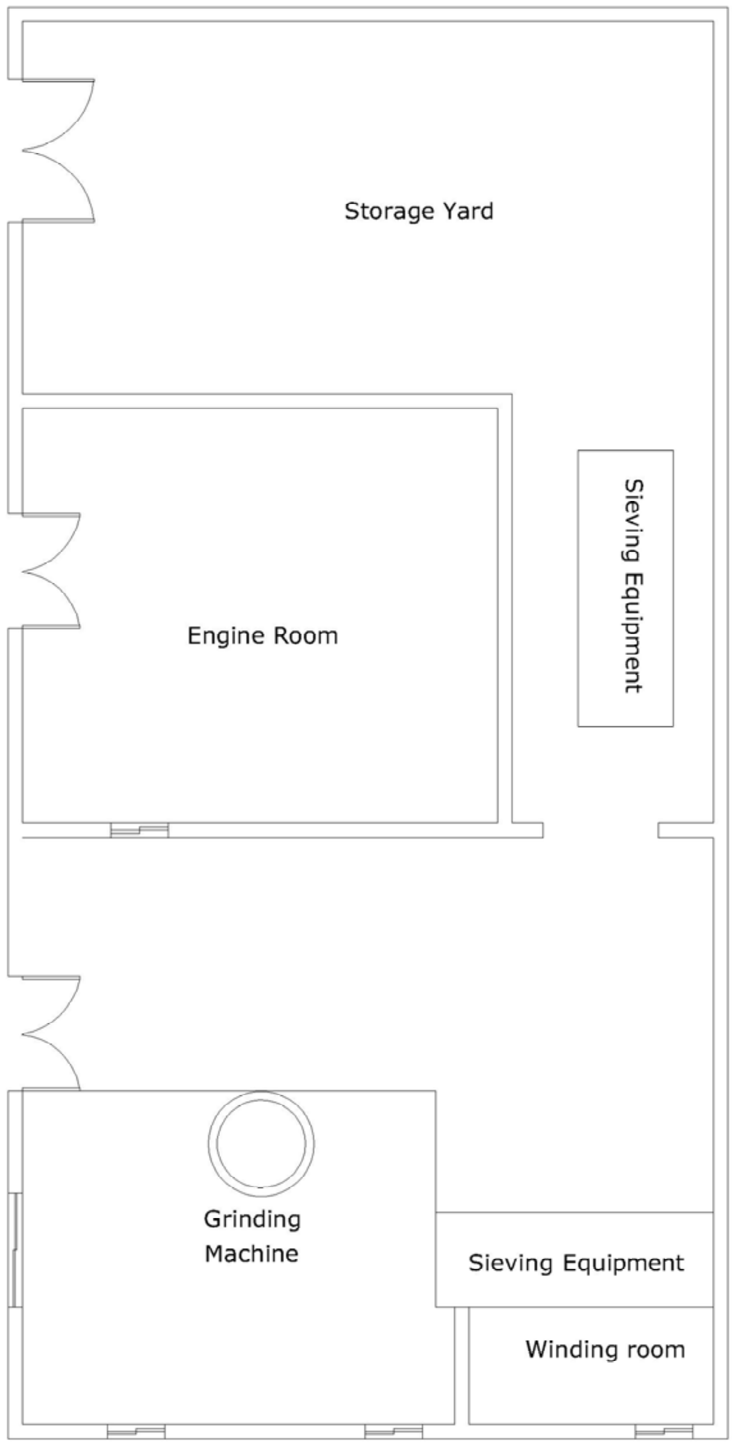


Figure 1: Typical Layout of a Flour Mill in GOQ

Figure 2: Typical Grinding Millstone Details

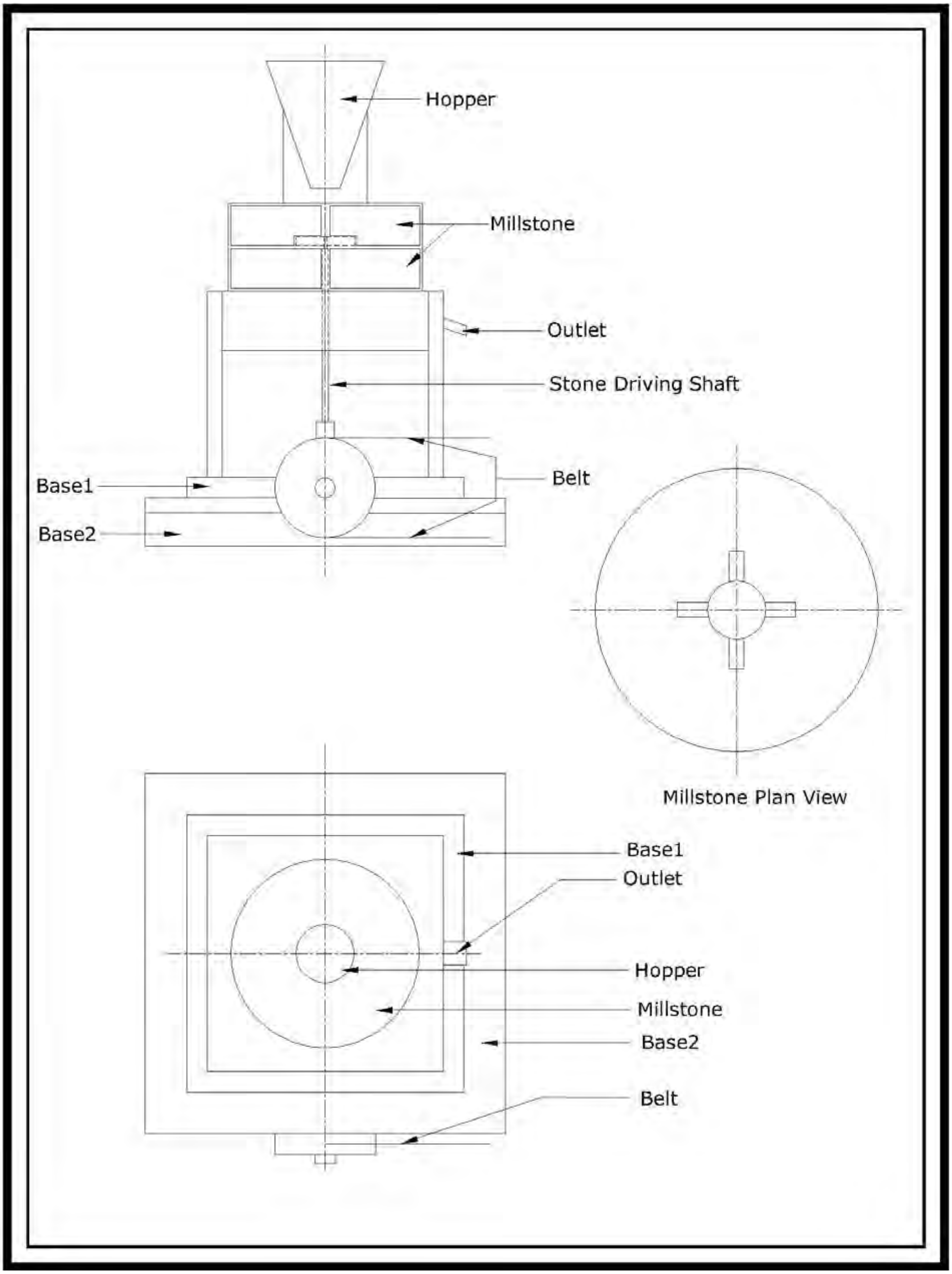


Figure 3: Distribution of Flour Mills in GOQ

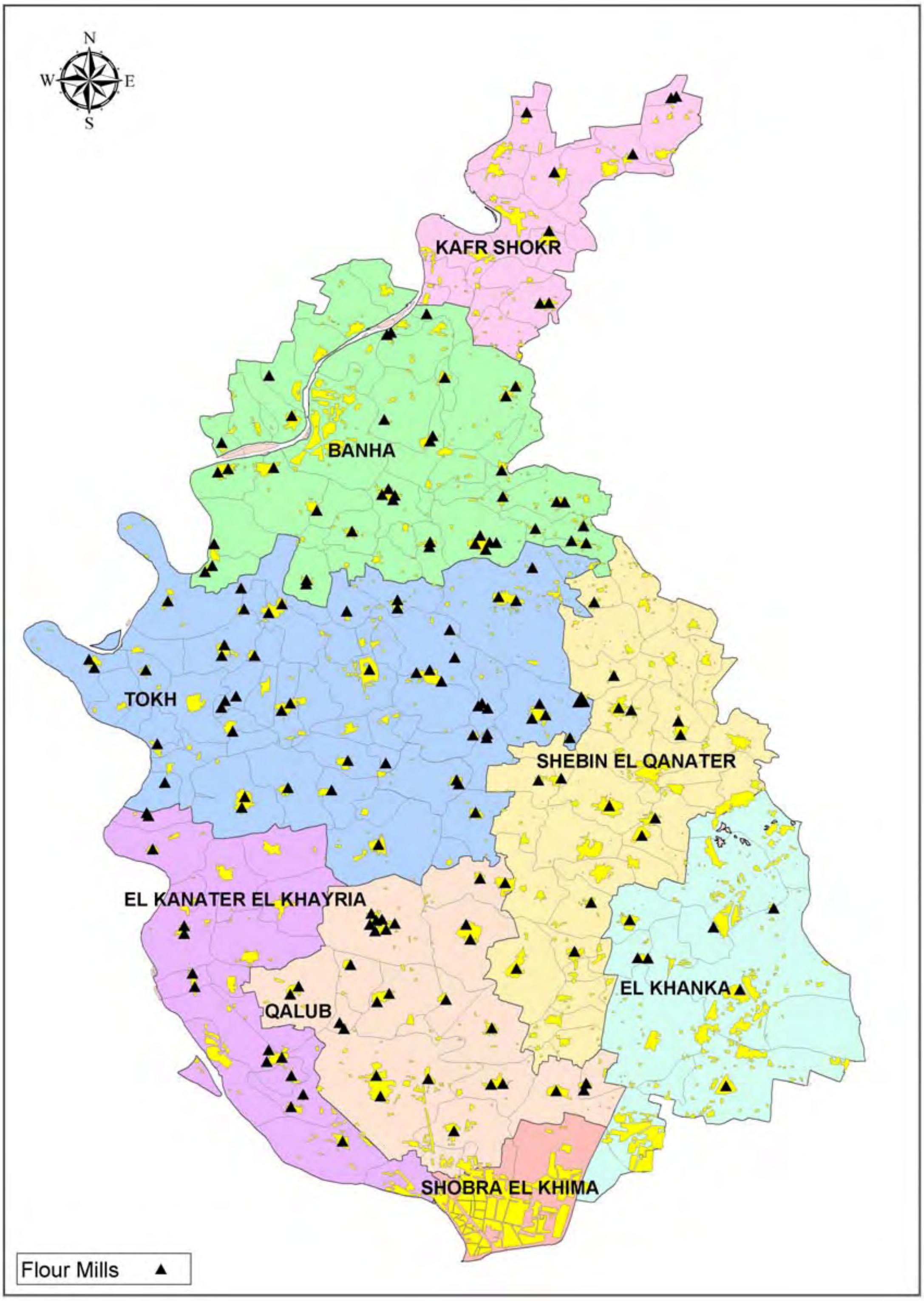


Figure 4: Distribution of Sampled Flour Mills

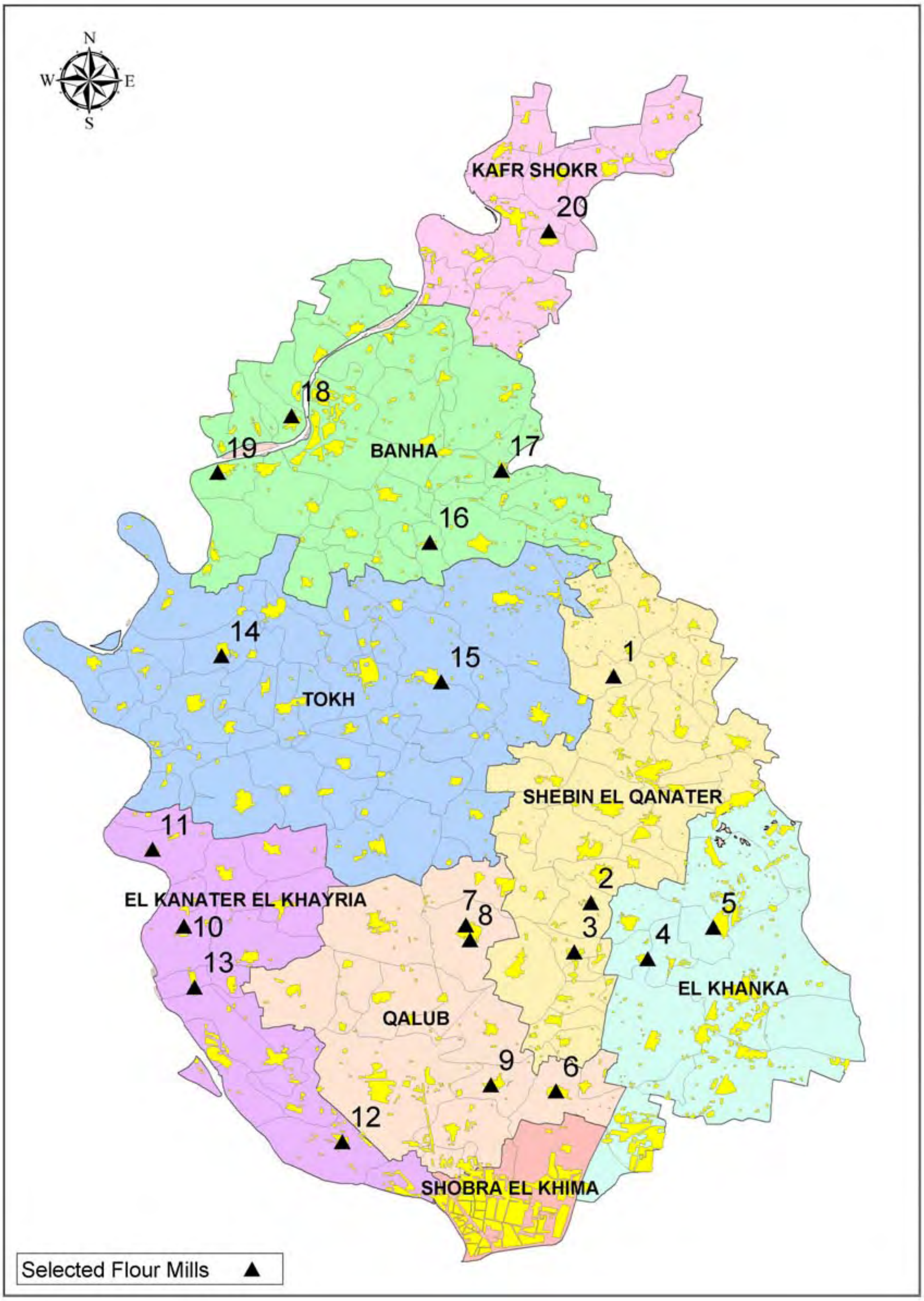


Table 5: Inventory of Sampled Mills

Mill No.	Mill Location ID	Ref. Code	Sampling Date (mm/dd/yy)	Layout Figure No. [a]
1	Samir Kamel Attallah, El Hazania, Shebeen El Kanater	HZ	05/28/07	A.1
2	Rizk Mahmoud Hassan, Noot Toha, Shebeen El Kanater	NT	05/28/07	A.2
3	Hanna Saad Habib, Kasheesh, Shebeen El Kanater	KSH	05/28/07	A.3
4	Badawy Bayoumi Abu Shabat, El Manayel, El Khanka	MEK	05/29/07	A.4
5	Mohamed Ahmed Ali, Kafr Abian, El Khanka	KA	05/29/07	A.5
6	Hassan Abdel Kareem Taha , Balqas Qalyoub	B	06/04/07	A.6
7	Mohamed Ibrahim Shadad, Tanan, Qalyoub	M1	06/04/07	A.7
8	Abdallah Mohamed Shadad, Tanan, Qalyoub	T	06/04/07	A.8
9	Abdul Monsef Noor El Deen, Koom Ashfeen, Qalyoub	K	06/04/07	A.9
10	Aida Tekla Gerges, Al Munirah, El Kanater	MT	06/05/07	A.10
11	Adel Mekkawy, Shoubra Shehab, El Kanater	SH	06/05/07	A.11
12	Summer El-Shafey- Mansheyat Abu El Gheit, El Kanater	G	06/05/07	A.12
13	Eid Negm Eid, Kafr El Shourafa, El Kanater	EK	06/05/07	A.13
14	Abdallah Mohamed Saleh, Emiai, Toukh	TAM	06/26/07	A.14
15	Adel El Sayed Omar, Mushtoher , Toukh	MUTA	06/26/07	A.15
16	Abdul Hameed Eid, Kafr El Arab, Banha	KEAB	06/27/07	A.16
17	Abdul Samee' Ismaeil Salam, Kafr Atallah, Banha	KAB	06/27/07	A.17
18	Al-Sayed Ghareeb, Kafr Abu Zekri, Banha	ZB	07/03/07	A.18
19	Samir Hussein Awad, Meit El Attar, Banha	MBS	07/03/07	A.19
20	Ahmed Abdallah El Ashry, Kafr Shoukr, El Bakasheen, Banha	KAAS	07/03/07	A.20

[a] Provided in Appendix A

Tables 6 and 7, respectively, present a description of the type and number of bulk and wipe samples collected from each mill. Figures A.1 through A.20 in Appendix A present layouts of the mills surveyed with the location of sampling points within each mill.

During the investigation, flour mills were found to grind corn and wheat grain received from local residents and local farms. Since a portion of the grain was received directly from the farms, this characterization was further expanded to investigate the potential for contamination at the source (i.e., crop contamination in the fields). Seven corn agricultural fields were randomly selected for further characterization. The agriculture field sampling included surface and root zone soil samples and wipe samples from plant leaves were collected for laboratory analysis. In addition, field irrigation water samples were collected from the irrigation channels, and where feasible from the main water source, typically an open water channel.

Table 8, presents a list of the sampled fields in addition to a description of the type and number of samples collected from each field. The locations of these fields are presented in Figure 5.

Figure 5: Distribution of Sampled Agricultural Fields

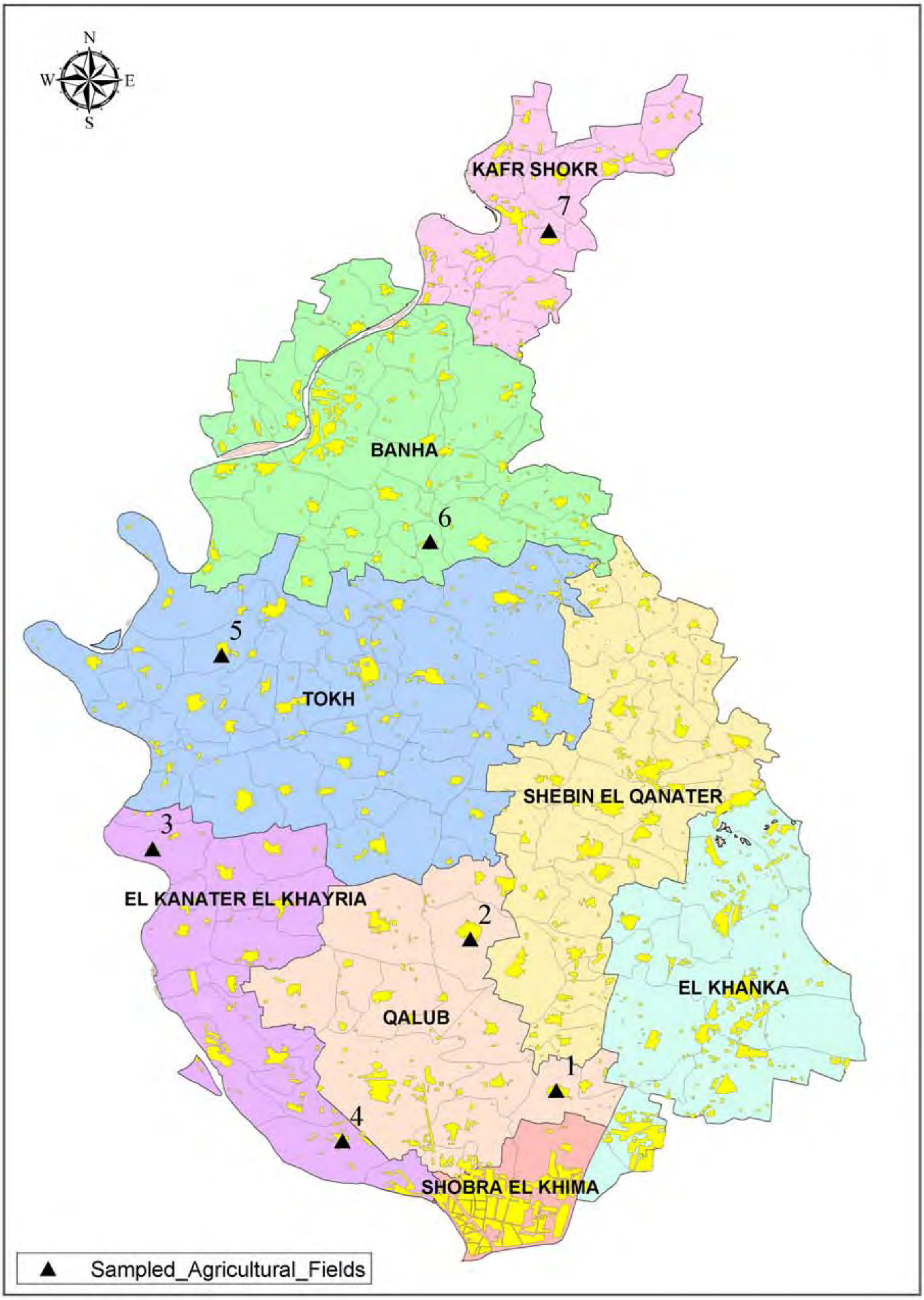


Table 6: Description of the Type and Number of Bulk Samples Collected at Each Mill

Mill No.	Ref. Code	Type and Number of Bulk Samples Collected					
		Grain		Flour		Dust	Other
		Corn	Wheat	Corn	Wheat		
1	HZ	1	1	1	1	5	1[a], 1[b]
2	NT	3	1	1	-	-	-
3	KSH	1	1	1	5	1	-
4	MEK	1	1	-	-	4	1[c]
5	KA	1	1	1	1	1	1[b]
6	B	1	1	1	2	2	1[c], 2[d]
7	M1	-	1	-	1	1	-
8	T	1	1	1	1	1	-
9	K	1	1	1	-	1	-
10	MT	2	1	1	-	2	-
11	SH	-	-	-	1	3	-
12	G	1	1	-	1	3	-
13	EK	1	1	1	-	3	-
14	TAM	-	-	1	-	1	-
15	MUTA	-	-	1	1	1	-
16	KEAB	-	1	-	-	1	-
17	KAB	1	1	1	1	1	-
18	ZB	-	1	-	4	-	1[d]
19	MBS	-	-	-	-	2	1[a]
20	KAAS	1	2	-	1	1	-

[a] Rice straw
[b] Flour dust: Flour that has brushed off the grinding machine
[c] Mixed flour samples: is the output of grinding two types of garins, such as corn and wheat, at the same time.
[d] Bread additives (Sin)

Table 7: Description of Locations and Number of Wipe Sampling Events

Mill No.	Ref. Code	Wipe Sampling, Location and Number					
		GE	FH	SV	WA	O	Total
1	HZ	2	2	3	1	-	8
2	NT	4	1	-	2	-	7
3	KSH	4	1	2	1	-	8
4	MEK	1	1	1	1	-	4
5	KA	3	1	1	1	-	6
6	B	2	2	1	1	-	6
7	M1	2	-	2	3	-	7
8	T	1	1	-	2	-	4
9	K	2	1	-	1	-	4
10	MT	3	1	1	1	-	6
11	SH	1	1	-	1	-	3
12	G	4	1	1	-	-	6
13	EK	4	1	-	-	-	5
14	TAM	1	1	-	1	-	3
15	MUTA	1	1	-	1	-	3
16	KEAB	1	1	-	1	-	3
17	KAB	1	1	-	1	-	3
18	ZB	1	1	-	1	-	3
19	MBS	2	3	-	1	-	6
20	KAAS	-	1	-	1	-	2

GE = Grinding Equipment FH = Feeding Hopper SV = Sieving Equipment
WA = Wall O= other

Table 8: Description of Agricultural Field Sampling Locations, Sample Types, and Number of Samples

Field No.	Field Location ID	Ref. Code	Sampling Date (mm/dd/yy)	Sample Type			
				SS	RZS	Wipes	Water
1	Balqas	B	06/04/07	8	8	8	2
2	Tanan	T	06/04/07	8	8	8	2
3	Shoubra Shehab	P	06/05/07	8	8	8	2
4	Abu El Gheit	A	06/05/07	8	8	8	2
5	Emiai, Toukh	TO	06/26/07	3	3	3	1
6	Kafr El Arab, Banha	BSS	06/27/07	5	5	5	1
7	Kafr Shoukr	KFSS	07/03/07	5	5	5	1

SS = Surface Soil
RZS = Root Zone Soil

Sampling Methods and Techniques

Different sampling methods were utilized during this investigation due to the number of sampling media. These methods are described below.

Corn and Wheat Bulk Grain Sampling--

Corn and wheat grain samples were collected from storage sacks via manual grab sampling using sterile latex, powderless gloves, or using stainless steel sampling spoons.

To ensure that cross contamination would not occur, the gloves were replaced and/or sampling instrument was decontaminated after each bulk sample was collected. All collected grain samples were placed in labeled, sterile, sealable plastic bags, and stored in a cooling ice box for shipment to the laboratory.

Wipe Sampling--

Wipe samples were collected from equipment, process component surfaces, walls, and windows at the sampled mills. Wipe samples were collected from plant leaves during the agricultural field sampling.

Two wipe sampling templates were developed for the purpose of this characterization. The first, a stainless steel template with an opening of 0.94 ft^2 (29.5 cm X 29.5 cm), was utilized for sampling within mills. The second, a hard plastic template with an opening of 0.14 ft^2 (8.7 cm X 15.4.5 cm), was utilized for sampling in the agricultural fields. The template was placed on top of the surface to be sampled, a wipe was extracted from its pack and pressed down firmly on the sampling surface at one end of the template. The wipe was then moved from side to side, within the boundary of the template, with an S-like motion. After wiping the entire surface, the wipe was folded in half and the clean side was used to wipe the same surface only this time in the top to bottom direction, with same S-like motion pattern.

During the sampling event, the sampler wore sterile, powderless gloves, and avoided contact between the wipe and any surface other than the sampling surface. To ensure that no cross contamination occurred, the gloves were replaced and the sampling template was sterilized/decontaminated following each sampling event.

All collected wipe samples were placed in labeled, sterile, sealable plastic bags and stored in a cooling icebox for shipment to the laboratory.

Dust Sampling--

Dust samples were collected from equipment and process component surfaces as well as from floors and building corners. Dust sampling was either conducted via manual grab sampling using sterile latex, powderless gloves, or using stainless steel sampling spoons/trowels.

To ensure that no cross contamination occurred, the gloves were replaced and the sampling instrument was decontaminated after each dust sample was collected. All collected dust samples were placed in labeled, sterile, sealable plastic bags, and stored in a cooling icebox for shipment to the laboratory.

Flour Sampling--

Depending on the type of grain delivered to the flour mill, different types of flour are produced as a result of the grinding process; namely, corn flour, wheat flour, and mixed flour (the output of grinding two types of grains, such as corn and wheat, at the same time). Therefore, the SAP for this characterization was developed to obtain, at least, one sample from the each flour type with an approximate size of 100 to 300 gm. Because the analysis requires using about 50 grams per sample, multiple samples were obtained from selected samples by splitting the sample for the purpose of QA/QC control.

Flour samples were either collected directly from the flour outlet nozzle or from the storage sacks. If they were collected from the outlet nozzle, they were allowed to flow directly into the sampling bag. However, if collected from storage sacks, sampling was conducted via manual grab sampling using sterile latex, powderless gloves, or using stainless steel sampling spoons/trowels.

To ensure that no cross contamination occurred, the gloves were replaced and the sampling instrument was decontaminated after each bulk sample was collected. All collected flour samples were placed in labeled, sterile, sealable plastic bags, and stored in a cooling icebox for shipment to the laboratory.

Soil Sampling--

Soil samples were collected from outside the mill buildings. Soil samples were collected in accordance with the Standard Practice for Field Collection of Soil Samples for Lead, using a grab sample procedure. A spoon or trowel was used to collect the sample of the surface soil layer.

For soil sampling in the agricultural fields, the same technique was adopted for collection of surface soil samples. For root zone soil collection, the plant was pulled from the ground to expose the root system and soil was manually collected from the plant root system, using sterile latex, powderless gloves. However, if deemed necessary, further soils were retrieved from the plant location.

To ensure that no cross contamination occurred, the gloves were replaced and/or sampling instrument was decontaminated after each bulk sample was collected. All collected soil samples were placed in labeled, sterile, sealable plastic bags, and stored in a cooling icebox for shipment to the laboratory.

Irrigation Water Sampling--

Irrigation water samples were collected at each of the selected fields. Sample collection was conducted via the bucket sampling method. Samples were collected mainly from the field irrigation channel system and where feasible, from the main water body (Teraa') that feeds the irrigation system.

At each sampling location, a rope was securely attached to the handle of a four liter bucket, which was then lowered into the sampled water body, using the rope, until it was partially filled with water. The retrieved water was then swirled in the bucket to clean it. The water was then safely disposed and the process was repeated three times. The fourth time, the bucket was lowered into the water body to retrieve the sample. The retrieved sample was then poured into 500 ml polyethylene bottles. Nitric acid was added to the sample to preserve it; the bottles were then sealed and placed in a cooling ice box for shipment to the laboratory.

<u>Sample Shipment for Analysis</u>

All samples were inspected to confirm that the containers were sealed and labeled, and that each sample had a unique reference code that was documented in the field records. A

Chain-of-Custody Form was completed following each field sampling event, and all samples were delivered to the laboratory with the Chain-of-Custody Form.

Sample Analysis

To satisfy the requirements of this investigation and for comparison with Egyptian standards, all attained samples were analyzed for four heavy metals of concern including lead (Pb), cadmium (Cd), arsenic (As) and mercury (Hg). Samples were sent to the Cairo University Center for Environmental Hazard Mitigation (CEHM) Laboratory for analysis. The laboratory used the Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) for analysis of the heavy metal content in the samples. This laboratory was selected because it has a lower detection limit that falls below the limits specified by the Egyptian standard. The detection limits for the analyzed parameters, as delivered by the laboratory, are listed in Table 9.

Table 9: Detection Limits for Analyzed Parameters Using the ICP-AES Device

Parameter	Detection Limits (ppm)	Standard Limits for metal contaminants in Food (ppm)
Lead (Pb)	0.0004	0.5
Cadmium (Cd)	0.0002	0.1
Arsenic (As)	0.002	0.5
Mercury (Hg)	0.005	0.5

All samples were analyzed following official methods of analysis specified by AOAC International (2002). Specific reference to analysis method for each sample type is as follows:

- Soil, dust, and wipe samples were analyzed in accordance with AOAC 990.08.
- Food samples (i.e., flour, grain, and flour additives) were analyzed in accordance AOAC 985.01.
- Water samples were analyzed in accordance with AOAC 984.27.

QA/QC Procedures

Details of laboratory QA/QC procedures, as provided by CHEM, are presented in Appendix C. The collected samples were delivered, accompanied by Chain-of-Custody Forms, to CHEM where they were analyzed for heavy metals of concern (i.e., lead, cadmium, arsenic, and mercury). Nineteen randomly selected food samples were split and sent to the same laboratory for QA/QC assessment.

For the purpose of QA/QC of the agricultural field soil and water samples, split samples were sent to the Egyptian Environmental Affairs Agency Central Laboratory for cross referencing. Discussion of the analytical results data quality obtained from the laboratory is provided in Appendix D.

ANALYSIS OF RESULTS

Flour Mills Results

Table 10 presents a summarized inventory of the number of samples collected throughout the sampling period in comparison with the number of samples analyzed by the laboratory (exclusive of QA/QC samples). As illustrated in Table 10, a total of 181 samples were analyzed out of 204 samples collected from 20 flour mills. The remaining samples were not reported due to problems in sample preparation.

Table 10: Flour Mills Sampling Inventory

Sampling Locations	Sample Type	Number of Samples Collected	Total	Number of Samples Analyzed	Total
Mills	Grain	32	204	32	182
	Flour	37		35	
	Additives[a]	3		3	
	Dust	36		34	
	Wipes	96		78	

[a] Locally known as "Raddah' added to flour at the mill

Tables B.1 through B.5 in Appendix B present the laboratory results obtained from the analysis of grain, flour, flour additives, soil, and wipe samples collected during the flour mill investigations. Results of split and cross-reference samples are also included in the table of results. A quantitative description of the analytical results of food samples with regards to their compliance with the Egyptian standard is presented in Table 11.

Table 11: Quantitative Description of Analysis Results Received

Sampling Location	Type of Sample	Levels Detected	Pb	Cd	As	Hg
Flour Mills	Grain	ND[a]	22	28	32	32
		ASL[b]	2			
		BSL[c]	8	4		
	Flour	ND[a]	7	30	35	35
		ASL[b]	6			
		BSL[c]	22	5		
	Flour Additives	ND[a]	1	3	3	3
		ASL[b]				
		BSL[c]	2			

a- ND = Non detected

b- ASL = Concentration detected was Above Standard Limit

c- BSL = Concentrations detected was Below Standard Limit

Assessment of analysis results from food samples (Tables B.1 through B.3) revealed the following observations:

- Arsenic and Mercury were not detected in any of the analyzed samples.

- Cadmium was detected in 13% of the analyzed samples (10 samples), none of which exceeded the standard limit of 0.1 mg/kg.

- Lead was detected in 57% of the analyzed samples (40 samples) of which 11% (8 samples) exceeded limits specified in the Egyptian standard.

Based on the above, lead is considered the contaminant of concern (COC) in food samples.

As stated earlier, analysis results of dust and wipe samples collected from the flour mills (Tables B.4 and B.5 in Appendix B) were compared to USEPA Region 9 Preliminary Remediation Goals (PRG's) for chemicals in residential areas. This comparison revealed that detectable concentrations of heavy metals are far below PRGs; thus suggesting that contamination is not attributed to an external source.

To assess the source of lead contamination in grain and flour, analytical results were graphically presented in Figures 6 and 7. These figures reveal that lead concentrations increased as a result of grinding. Prior to grinding, the percentage of grain samples that attained a detectable level of Pb was 31% (10 Samples) of which only 6% (2 samples) exceeded limits specified by Egyptian standards. After grinding, the percentage of flour samples that attained detectable Pb levels was about 79% (30 samples) of which 16% (6 samples) exceeded Egyptian standard limits.

A "type-to-type" comparison of the analytical results of grain and flour samples was conducted. Specifically, the analytical results of one type of grain (i.e., corn and wheat) were compared to that of the same type flour. . It is worth noting that the actual number of mills, on which this comparison is based, is only eleven mills. The analytical results obtained for nine mills, namely; MEK, MT, SH, TAM, MUTA, KEAB, ZB, MBS, and KAS were not used because the same type of grain and flour samples were not collected or analysis results of same type grain and flour samples were not reported. The result of this comparison is illustrated in Figure 8. This comparison revealed that lead concentrations increased as a result of the grinding process in 10 out of 11 mills (i.e., 90% of the mills). This confirms that the grinding process is the main potential source of lead contamination.

Furthermore, the results obtained for cadmium levels reveal no significant increase in concentrations as a result of the grinding process. Prior to grinding, the percentage of grain samples that attained a detectable level of Cd was 13% (4 samples), none of which exceeded Egyptian standard limits. After grinding, the percentage of flour samples that attained Cd levels was 16% (5 samples) with no results exceeding Egyptian Standard limits.

Agricultural Fields Results

A total of 90 soil, 45 wipe, and 11 water samples were collected from seven agricultural fields in the GOQ. Analytical results for soil, wipe, and water samples collected from the investigated fields are presented in Tables B.6 through B.8 in Appendix B.

Analyses results suggest that the potential for crop contamination at the field is not anticipated. Sixty-nine soil samples were found to attain a detectable level of lead. The maximum detected level was 0.02 mg/kg which is far below the standard limit of 70 mg/kg. With respect to wipe samples only one sample revealed a detectable level of lead.

The results of water sample analysis provide comparable indications as those provided by field soil and wipe samples. However, one water sample was found to have a lead concentration that exceeded the standard limit (0.05 mg/l) by approximately 16%.

Figure 6: Comparison between Number of Grain Samples Collected and Samples that Exceeded Guideline Limits

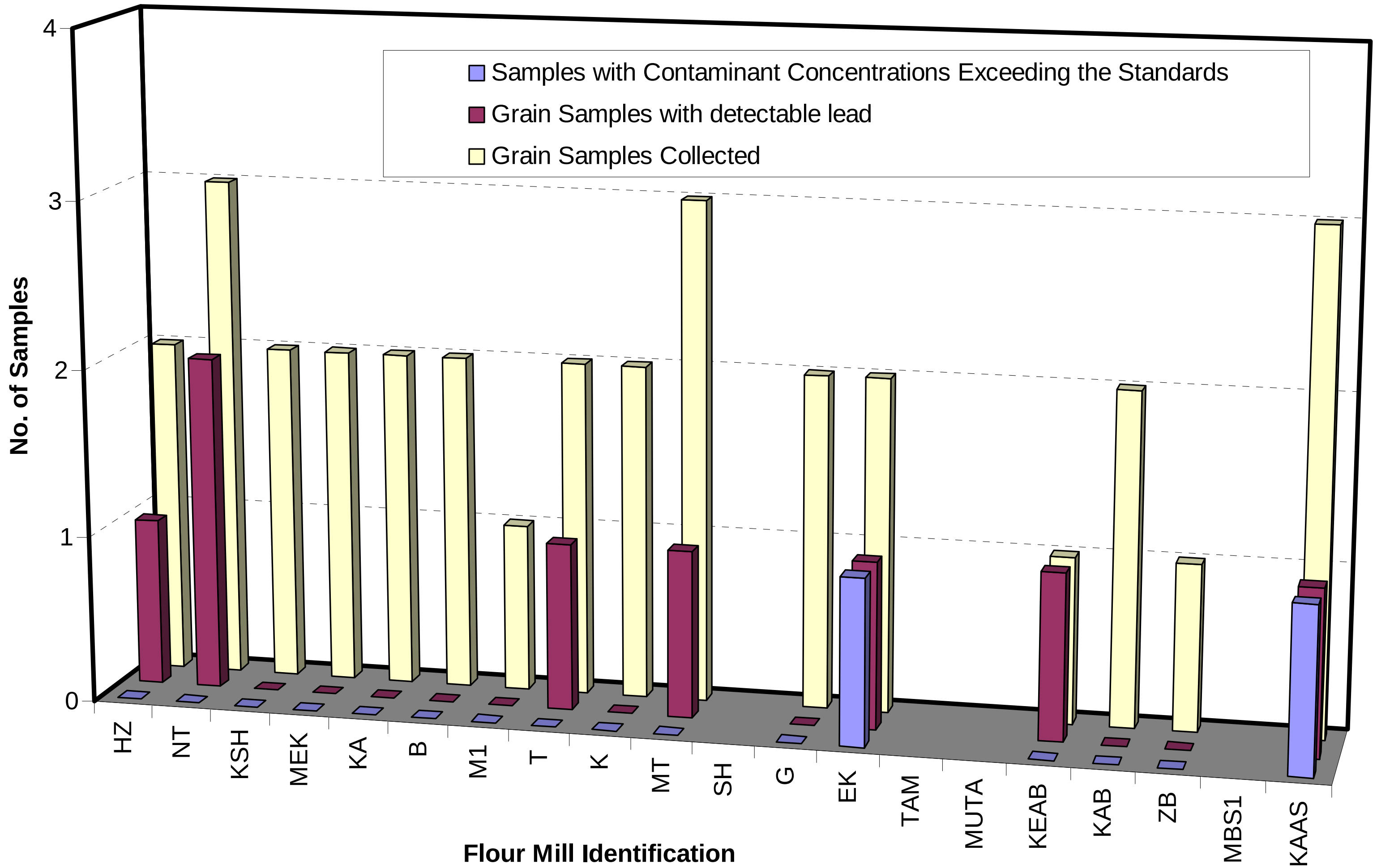


Figure 7: Comparison between the Number of Flour Samples Collected and Samples that Exceeded Guideline Limits

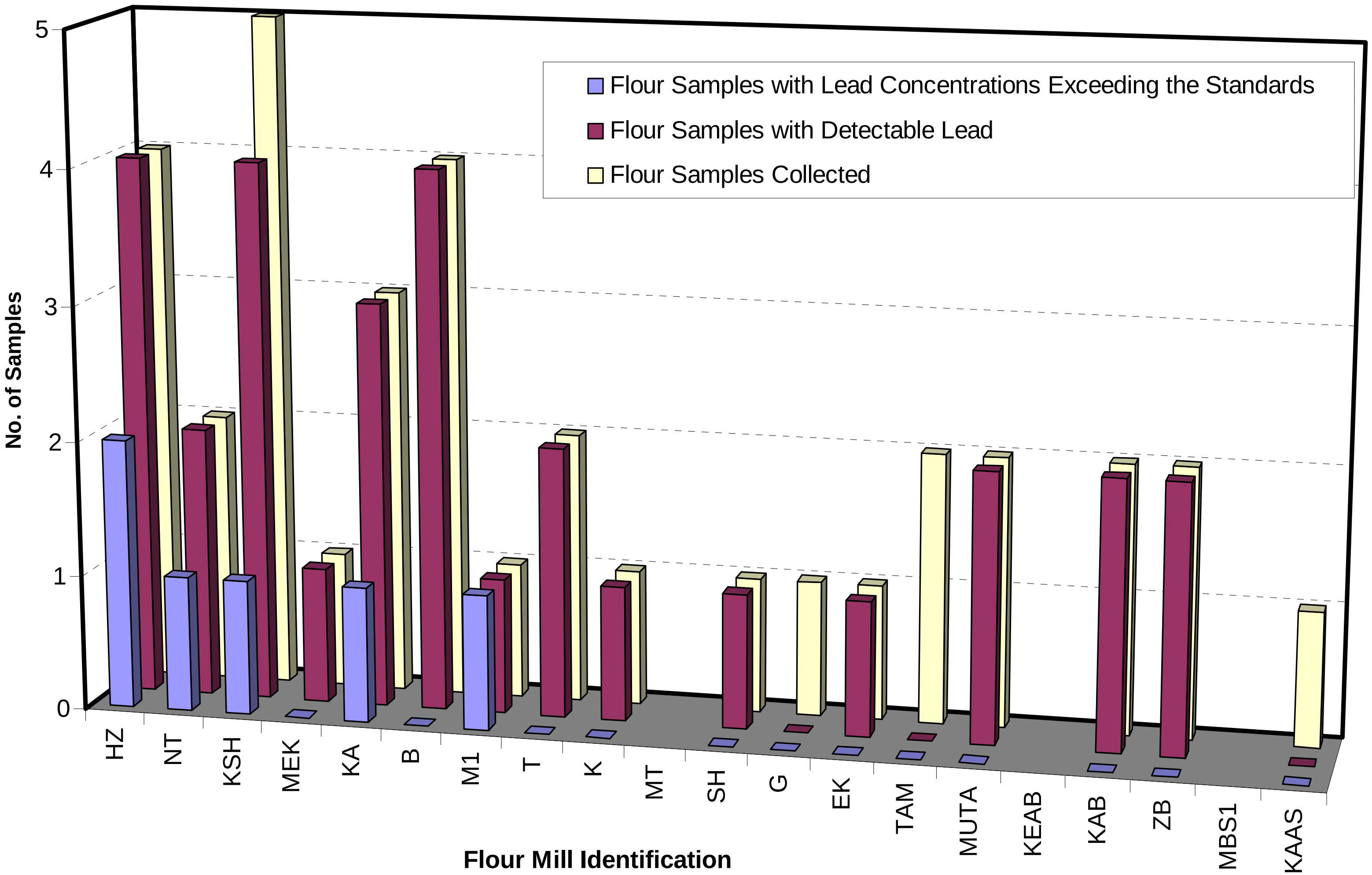
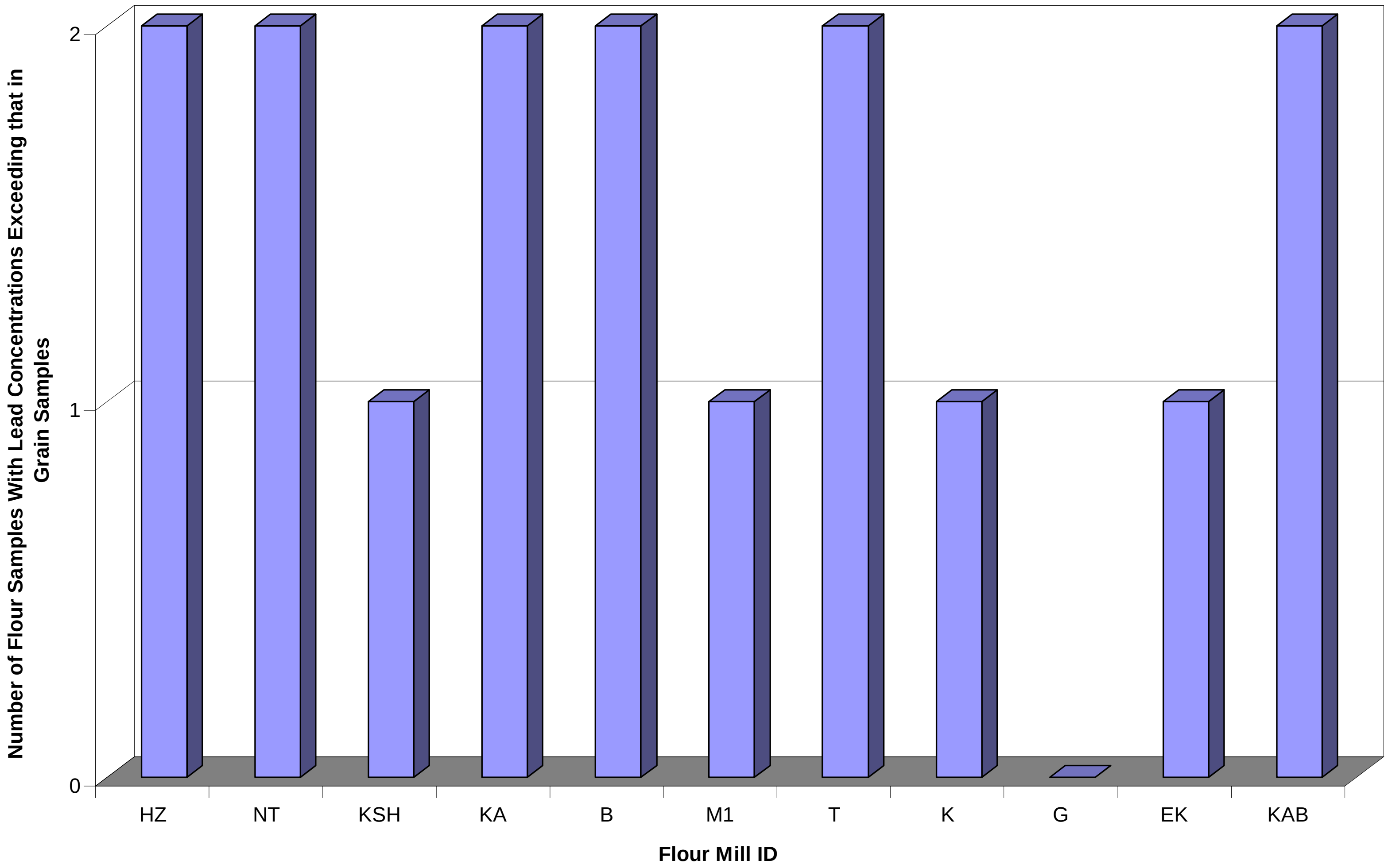


Figure 8: Number of Samples that revealed an Increase in Lead Concentration from Grain to Flour Form



EVALUATION OF THE STONE GRINDING MACHINE

In light of the above conclusions, a review of technical literature was performed to confirm/ assess the potential of lead contamination in flour resulting from the stone grinding machines. According to this review, stone grinding machines, in addition to smelting, are considered as one of the major sources for lead contamination in developing countries (Henry, 2007). Furthermore, outbreaks of lead poisoning due to grain grinding in rural flour mills were reported in some Middle East countries, e.g., Egypt (Henry, 2007) and Palestine (Richter et al., 2000), as well as in other regions such as the Balkans and South America. Lead contamination in flour was attributed to the use of molten lead in attaching the upper grinding stone to the metallic rynd. As the grinding surfaces wears down from repeated use, the lead is unevenly deposited in the flour causing low level contamination punctuated by episodes of very high contamination. In addition, molten lead is reported to be used to fill cracks in the grinding stone resulting in lead eventually being ground into the flour.

In July 2007, LIFE-Lead personnel revisited the flour mill located in Abou El Gheit village (Al Kanater El Khyria District). This mill was one of the two flour mills that were suspected to be the common link in the reported acute lead poisoning of two families. The purpose of this visit was to identify the source of lead contamination in the grinding machine. During this visit, the grinding machine was dismantled and samples were collected from machine components that were believed to come in contact with the flour/grain during grinding. Specifically, samples were obtained from the following:

- Metallic strap that was observed around the upper and lower grinding stone; and
- Mill rynd.

Sampling was conducted by scratching the surfaces of the metallic strap and mill rynd using a stainless steel tool. Samples collected were placed in labeled, sterile, sealable plastic bags and shipped for analysis. Samples were analyzed using an XRF device and the results are provided in Table 12.

Table 12: Analysis Results of Samples from Metallic Components of Grinding Machine

Sample	Pb ppm	Cd ppm	As Ppm	Hg ppm
Metallic strap	15.61	ND	ND	ND
Mill rynd	281.7	ND	ND	ND

To complement the evaluation of the grinding machine, seven chips of grinding stone were obtained from a local manufacturer and sent to CHEM laboratory for analysis. Analysis results are provided in Table 13.

Table 13: Analysis Results of Grinding Stone Chips

Sample	Pb ppm	Cd ppm	As Ppm	Hg Ppm
Chip 1	5.016	0.034	ND	ND
Chip 2	4.000	1.691	ND	ND
Chip 3	2.198	1.401	ND	ND
Chip 4	1.438	2.804	ND	ND
Chip 5	2.507	0.745	ND	ND
Chip 6	2.100	1.703	ND	ND
Chip 7	5.117	2.031	ND	ND

Analytical results reveal that lead was detected in the mill rynd and stone chips. Therefore, excessive wear and tear of these components during grinding could be the potential source of lead in the flour samples.

PRELIMINARY HUMAN HEALTH RISK EVALUATION FOR THE FLOUR MILLS

The concentrations of the above mentioned analyzed metals were compared to the Egyptian Standard 2360 – 1993 for Maximum Levels of Heavy Metal Contaminants in Food. Lead was the only contaminant which exceeded the standards in some samples of flour (i.e., corn and wheat).

The average concentration of lead in flour did not exceed the Egyptian Standard 2360 – 1993 for Maximum Levels of Heavy Metal Contaminants in Food. However a preliminary risk evaluation was conducted using the Integrated Exposure Uptake Biokinetic Model. This preliminary risk evaluation is used to estimate the risk for children under 7 years who will eat the bread prepared using this flour.

This preliminary risk evaluation estimated blood-lead concentrations for children under 7 years of age using the Integrated Exposure Uptake Biokinetic Model (IEUBK) developed by the USEPA. The USEPA standard for lead in blood is that no more than 5 percent of children in the study population would have blood lead levels of 10 micrograms (µg) of lead per deciliter (dL) of blood.

The USEPA has recommended the IEUBK model as a predictor of potential long-term blood lead levels for children in residential settings. Comparisons between measured blood lead data and IEUBK model predictions have demonstrated close agreement between mean observed and predicted blood lead concentrations and between observed and predicted exceedances of 10 µg /dL in children (USEPA, 1998).

The IEUBK model is used to predict the risk of elevated blood lead levels in children 0 to 7 years old that are exposed to lead from multiple sources. The model also predicts the risk (e.g., probability) that a typical child, when exposed to media-specified lead concentrations, will have a lead blood level greater or equal to the level associated with adverse health effects (10 (µg /dL) (USEPA, 2004).

The IEUBK model uses four interrelated modules (exposure, uptake, biokinetic, and probability distribution) to estimate blood lead (PbB) levels in children exposed to lead from several sources and by several routes (USEPA, 2002a). A brief summary of each module is provided below.

- The exposure module uses lead concentrations in the environment and the rate at which a child breathes or ingests contaminated media to determine lead exposure. Media that can act as sources of lead include air, soil, water, diet, and other sources such as lead paint. The exposure module calculates the intake of lead from each medium for use in the uptake module.
- The uptake module modifies the lead intake rates using absorption factors to predict the uptake of lead from lungs and the gastrointestinal tract. Uptake is defined as the fraction of the total lead intake that crosses from the lungs and gastrointestinal tract to the bloodstream. The lead intake rates and absorption factors are both age and media specific. The total rate of lead uptake is calculated for use in the biokinetic module.
- The biokinetic module addresses the transfer of absorbed lead between blood and other body tissues in addition to the elimination of lead from the body via urine, feces, skin, hair, and nails and the storage and/or disposition of lead in the extra-cellular fluid, red blood cells, liver, kidney, spongy bone, compact bone (femur), and other soft tissue. The total amount of lead in each body compartment is age dependent. Based on site-specific environmental exposures input by the user, a geometric PbB concentration is predicted.
- The probability distribution module uses the geometric PbB concentration to estimate a plausible distribution of PbB concentrations. From this distribution, the model calculates the probability or risk that a child's PbB concentration will exceed a user-selected PbB level of concern (typically 10 μg /dL).

The assumptions used were as follows:

- All default of values of the model where used except for the dietary values.

- Children below 1 year of age were excluded from this assessment as it is assumed that they are either breast fed or use formulas.

- The ingestion rate of bread is based on an assumption that a child resident will eat 3 pita breads (balady bread) per day. The standard weight of pita bread is 130 gm. We assumed that flour constitutes half of this weight accordingly the daily intake is as follows:

  Daily dietary lead intake = Weight of flour in pita bread (g) x Average lead concentration (μg /g) x 3 pita breads per day

  Daily dietary lead intake (μg/day) = 65 (g) x 0.47 (μg /g) x 3 pita/day = 91.65

Preliminary risk assessment using the IEUBK model showed the following:

- The geometric mean blood lead level is 13.3 μg /dl.

- The percentage of children who will have a BLL above 10 μg /dl is 72.7%, and the target is 5%.

CONCLUSIONS

The major findings obtained from the characterization study conducted at selected flour mills and agricultural fields in the GOQ are summarized below.

- The contaminant of concern in grain and flour samples was found to be lead. Detectable levels of cadmium in a few of the samples were below the standard limit. No levels of Arsenic or Mercury were detected in any of the analyzed samples.

- Analytical results of dust and wipe samples indicate that heavy metal concentrations were far below PRGs; thus, reducing the likelihood of heavy metal contamination of food samples from external sources.

- Similarly, analysis results of agricultural field samples (i.e., soil, water, and wipe samples) indicate that heavy metal concentrations were far below PRGs; thus, reducing the likelihood of heavy metal contamination of crops during the cultivation phase.

- Concentrations of lead in grain and flour samples were found to increase as a result of the grinding process. Analytical results revealed that an increase in lead concentrations was detected in ten out of eleven flour mills.

- Based on the analytical results of grain / flour samples, it can be inferred that the release/occurrence of lead in flour is a random process. The release of lead into flour generally depends on several factors such as the type of grain (soft or hard), age of the grinding machine, and adjustable spacing between the upper and lower grinding stone. This characterization is considered a snapshot in time and cannot be used to identify contaminated flour mills, unless random sampling of flour samples over an extended period of time is performed.

- Based on analytical results of flour and grain samples, the preliminary Human-Health Risk Evaluation was performed using analytical result of flour and grain samples. This evaluation showed that 72.7 percent of children between 0 and 7 years in age will have a BLL above 10 μg /dl. This percentage is higher than the USEPA standard of 5 percent.

- An overall assessment of the analytical results, which takes into account data quality indicators (i.e., precision, accuracy, representativeness, comparability, and completeness) indicates that the analytical data for samples collected from the selected flour mills are acceptable for their intended use.

RECOMMENDATIONS

The following recommendations are proposed based on the review of the site characterization data for the GOQ surveyed flour mills and agricultural fields:

- Based on analyses results, the source of contamination can be attributed to the grinding mechanism. Based on sampling and site visits, a number of process components may contribute to heavy metal levels, including; the stone, metallic rynd, and strap belt. Alternatives to the current grinding process should be investigated to produce flour with heavy metal contaminant levels less than the standard.

The LIFE-Lead project did a preliminary evaluation of other grinding systems that are being used and that could be manufactured in Egypt. The most economical system includes the use of two rotating metal drums that are driven by a motor and belt system. They can be manufactured locally and the initial cost for the design and manufacture of a system capable of processing one and two tons per day of grain ranged between $20,000 and $25,000, respectively.

- International standards for maximum levels of heavy metal contaminant in flour and grain are less that that specified in the Egyptian Standards. Given that the Egyptian standard latest revision is dated back to 1993, the standards should be updated to reflect the current level of knowledge pertaining to the effects of heavy metal contaminants in foods to be used for human consumption.

- The risk assessment presented in this report is considered preliminary; therefore, it is recommended that further random sampling over an extended time period be performed to develop a reliable risk assessment. The sampling and analysis should be conducted by the Egyptian Environmental Affairs Agency Central Laboratory staff who participated in the data collection of this report.

- Due to the random nature of lead release in flour as a result of grinding, it is recommended that additional sampling be conducted over an extended period of time to identify lead contaminated flour mills.

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APPENDIX A: LAYOUT OF SAMPLED FLOUR MILLS

APPENDIX B: ANALYTICAL RESULTS OF COLLECTED SAMPLES

Table B.1: Analysis Results of Grain Samples from Flour Mills

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd Ppm	As ppm	Hg ppm
1	El Hazania – Shebeen El Anater	HZ-BG1 (Corn Grain)	0.040000	ND	ND	ND		0.05354	0.0069	ND	ND
		HZ-BG2 (Wheat Grain)	ND	0.01106	ND	ND					
2	Rizk Mahmoud Hassan- Noot Taha- Shebeen El Anater	NT-BG1 (Wheat Grain)	ND	ND	ND	ND		ND	ND	ND	ND
		NT-BG2 (Corn Grain)	0.044000	ND	ND	ND		0.03500	ND	ND	ND
		NT-B3 (Grain)	0.042700	0.02100	ND	ND					
3	Hanna Saad Habib Kashesh Shebeen El Kanater	KSH-BG1 (Wheat Grain)	ND	0.01500	ND	ND		ND	ND	ND	ND
		KSH-BG2 (Corn Grain)	ND	ND	ND	ND		ND	ND	ND	ND
4	Badawy Bayoumi El Manayel – El khanka	MEK-BG1 (Corn Grain)	ND	ND	ND	ND					
		MEK-BG2 (Wheat Grain)	ND	ND	ND	ND					
5	Kafr Ebian- Khanka	KA-BG1 (Corn Grains)	ND	ND	ND	ND		ND	ND	ND	ND

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd Ppm	As ppm	Hg ppm
		KA-BG2 (Wheat Grains)	ND	ND	ND	ND					
6	Hassan Abdel Kareem Belquas Qalyoub	B-BG1 (Wheat Grain)	ND	ND	ND	ND					
		B-BG2 (Corn Grain)	ND	ND	ND	ND					
7	Mohamed Shadad-Tanan Qalyoub	M1-BG1 (Wheat Grain)	ND	0.003610	ND	ND					
8	Abdallah Shadad-Tanan Qalyoub	T-B2 (Wheat Grain)	0.041000	ND	ND	ND					
		T-B3 (Corn Grain)	ND	ND	ND	ND					
9	Abdel Monsef Noor El Deen- Koom Ashfeen- Qalyoub	K-B1 (Corn Grain)	ND	ND	ND	ND					
		K-B2 (Wheat Grain)	ND	ND	ND	ND					
10	Aida Tekla Gerges – Al Munirah	MT-BG1 (Corn Grain)	ND	ND	ND	ND					
		MT-BG2 (Wheat Grain)	ND	ND	ND	ND					

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd Ppm	As ppm	Hg ppm
		MT-BG3 (Livestock Corn Grain)	0.034	ND	ND	ND					
12	Summer El-Shafey-Mansheyat Abu El Gheit, El Kanater	G-B3 (Corn Grain)	ND	ND	ND	ND					
		G-B4 (Corn Grain)	ND	ND	ND	ND					
13	Eid Negm Eid—Kafr El Shourafa Kanater	EK-BG1 (Wheat Grain)	0.510	ND	ND	ND					
		EK-BG2 (Corn Grain)	ND	ND	ND	ND					
16	Abdul Hameed Eid – Hafr El Arab - Banha	KEAB1 (Wheat Grain)	0.031200	ND	ND	ND					
17	Abdul Samee' Ismaeil Salam - Kafr Atallah - Banha	KABG1 (Corn Grains)	ND	ND	ND	ND					
		KABG2 (Wheat Grains)	ND	ND	ND	ND					
18	Al-Sayed Ghareeb – Kafr Abu Zekri	ZB1 (Wheat Grain)	ND	ND	ND	ND					
20	Ahmed Abdallah El Ashry – Kafr Shoukr	KAAS1 (Corn Grain)	6.278	ND	ND	ND					

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd Ppm	As ppm	Hg ppm
		KAAS2 (Wheat Grain)	ND	ND	ND	ND					
		KAAS3 (Livestock Wheat Grain)	ND	ND	ND	ND					
Limits of Heavy Metals in Grains			**0.5**	**0.1**	**0.5**	**0.05**					

Table B.2: Analysis Results of Flour Samples from Flour Mills

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
1	El Hazania – Shebeen El Anater	HZ-B1 (wheat flour)	1.227	0.006	ND	ND		1.40	ND	ND	ND
		HZ-B2 (Dust Flour)	0.0010	ND	ND	ND					
		HZ-B3 (Corn Flour)	5.150	ND	ND	ND		5.042	0.0020	ND	ND
		HZ-B4 (Mixed Flour)	0.0013	ND	ND	ND					
2	Rizk Mahmoud Hassan- Noot Taha- Shebeen El Anater	NT-B2 (Wheat Flour)	0.043	ND	ND	ND		0.048	ND	ND	ND
		NT-B4 (Corn Flour)	1.87	0.003	ND	ND		ND	ND	ND	ND
3	Hanna Saad Habib Kashesh Shebeen El Kanater	KSH-B1 (Wheat Flour)	ND	ND	ND	ND					
		KSH-B2 (Corn Flour)	0.006	ND	ND	ND					
		KSH-B3 (Wheat Flour, 2nd Grade)	0.0091	ND	ND	ND					
		KSH-B4 (wheat flour, off Sieve)	3.5	ND	ND	ND		3.773	ND	ND	ND
		KSH-B5 (Wheat Flour, 3rd Grade)	0.0059	ND	ND	ND					
4	Badawy Bayoumi El Manayel – El khanka	MEK-D1 (Mixed Flour)	0.0011	ND	ND	ND					

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
5	Kafr Ebian-Khanka	KA-B1 (Corn flour)	0.024	ND	ND	ND		0.029	ND	ND	ND
		KA-B2 (Wheat flour)	1.5380	0.032	ND	ND		1.45	0.0290	ND	ND
		KA-B3 (Flour Dust)	0.012	ND	ND	ND					
6	Hassan Abdel Kareem Belquas Qalyoub	B-B1 (Wheat Flour)	0.01	ND	ND	ND					
		B-B2 (Corn Flour)	0.0112	ND	ND	ND					
		B-B3 (Stored Wheat Flour)	0.0075	ND	ND	ND					
		B-B4 (Mixed Flour)	0.0026	ND	ND	ND					
7	Mohamed Shadad- Tanan Qalyoub	M1-D1 (Wheat Flour)	2.40	0.004	ND	ND		2.363	0.007	ND	ND
8	Abdallah Shadad- Tanan Qalyoub	T-B1 (Wheat Flour)	0.001	ND	ND	ND					
		T-B4 (Corn Flour)	0.0093	ND	ND	ND					
9	Abdel Monsef Noor El Deen- Koom Ashfeen- Qalyoub	K-D2 (Corn Flour)	0.09	ND	ND	ND					
10	Aida Tekla Gerges – Al Munirah	MT-B1 (Corn Flour)	Not Reported								

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
11	Adel Mekkawy Shoubra Shehab	SH-B1 (Flour)	0.014	0.001	ND	ND					
12	Summer El-Shafey-Mansheyat Abu El Gheit, El Kanater	G-D4 (Wheat Flour)	ND	ND	ND	ND					
13	Eid Negm Eid—Kafr El Shourafa Kanater	EK-B1 (Corn Flour)	0.354	ND	ND	ND					
14	Abdallah Saleh - Toukh	TAM1 (Corn Flour)	ND	ND	ND	ND					
		TAM2 (Dust)	ND	ND	ND	ND					
15	Adel Omar – Mushtoher - Toukh	MUTA1 (Wheat Flour)	0.0171	ND	ND	ND					
		MUTA2 (Corn Flour)	0.015	ND	ND	ND					
17	Abdul Samee' Ismaeil Salam - Kafr Atallah - Banha	KAB1 (Corn Flour)	0.0130	ND	ND	ND					
		KAB2 (Wheat Flour)	0.0031	ND	ND	ND					
18	Al-Sayed Ghareeb –Kafr Abu Zekri	ZB2 (Wheat Flour 1st Grade)	Not Reported								
		ZB3 (2nd Grade)	Not Reported								

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
		ZB4 (3rd Grade)	ND	ND	ND	ND					
		ZB6 (Wheat Flour)	ND	ND	ND	ND					
20	Ahmed Abdallah El Ashry – Kafr Shoukr	KAAS4 (Wheat Flour)	ND	ND	ND	ND					
Limits of heavy metal contaminants in Flour			0.5	0.1	0.5	0.05					

Table B.3: Analysis Results of Food Additive from Flour mills

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
6	Hassan Abdel Kareem Belquas Qalyoub	B-B5 (Raddah)	0.0020	ND	ND	ND					
		B-B6 (Raddah)	0.0039	ND	ND	ND					
18	Al-Sayed Ghareeb –Kafr Abu Zekri	ZB5 (Flour Additive, Sin)	ND	ND	ND	ND					

Table B.4: Analysis Results of Dust Samples from Flour Mills

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
1	El Hazania – Shebeen El Anater	HZ-D1 (Dust)	0.0137	ND	ND	ND					
		HZ-D2 (Dust)	ND	ND	ND	ND					
		HZ-D3 (Dust)	0.0073	ND	ND	ND					
		HZ-D4 (Dust)	0.0150	ND	ND	ND					
		HZ-D5 (Dust)	0.0234	ND	ND	ND					
2	Rizk Mahmoud Hassan- Noot Taha- Shebeen El Anater	NT-B1 (Dust)	0.0029	ND	ND	ND					
3	Hanna Saad Habib Kashesh Shebeen El Kanater	KSH-B6 (Dust)	2.714	ND	ND	ND		2.533	ND	ND	ND
		KSH-D2 (Dust)	ND	ND	ND	ND					
4	Badawy Bayoumi El Manayel – El khanka	MEK-D2 (Dust)	0.033	ND	ND	ND					
		MEK-D3 (Dust)	0.013	ND	ND	ND					
		MEK-D4 (Dust)	0.010	ND	ND	ND					
		MEK-D5 (Dust)	0.1659	ND	ND	ND					
5	Kafr Ebian- Khanka	KA-D1 (Dust)	0.073	ND	ND	ND					

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
		KA-D2 (Soil)	0.0166	ND	ND	ND					
6	Hassan Abdel Kareem Belquas Qalyoub	B-B7 (Dust)	0.097	ND	ND	ND					
		B-B8 (Dust)	0.0171	ND	ND	ND					
7	Mohamed Shadad- Tanan Qalyoub	M1D2 (Dust)	0.006	ND	ND	ND					
8	Abdallah Shadad- Tanan Qalyoub	T-D1 (Dust)	0.033	ND	ND	ND					
9	Abdel Monsef Noor El Deen- Koom Ashfeen- Qalyoub	K-D1 (Dust)	0.038200	ND	ND	ND					
10	Aida Tekla Gerges – Al Munirah	MT-B2 (Dust)	0.017	ND	ND	ND					
		MT-B3 (Dust)	0.0097	ND	ND	ND					
11	Adel Mekkawy Shoubra Shehab	SH-B2 (Dust)	0.009	ND	ND	ND					
		SH-D1 (Dust)	Not reported								
		SH-D2 (Dust)	Not Reported								
12	Summer El-Shafey-	G-D1 (Dust)	ND	ND	ND	ND					

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
	Mansheyat Abu El Gheit, El Kanater	G-D2 (Dust)	ND	ND	ND	ND					
		G-D3 (Dust)	0.0115	ND	ND	ND					
13	Eid Negm Eid—Kafr El Shourafa Kanater	EK-B2 (Dust)	0.0026	ND	ND	ND					
		EK-B3 (Dust)	ND	ND	ND	ND					
		EK-B4 (Dust)	0.0153	ND	ND	ND					
14	Abdallah Saleh - Toukh	TAM2 (Dust)	ND	ND	ND	ND					
15	Adel Omar – Mushtoher - Toukh	MUTA-D1 (Dust)	0.0153	ND	ND	ND					
16	Abdul Hameed Eid – Hafr El Arab - Banha	KEAB-D1 (Dust)	0.0044	ND	ND	ND					
17	Abdul Samee' Ismaeil Salam - Kafr Atallah - Banha	KABD1 (Dust)	ND	ND	ND	ND					
19	Samir Awad – Meit El Attar – Banha	MBS2 (Dust)	ND	ND	ND	ND					
		MBS3 (Dust)	ND	ND	ND	ND					

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
20	**Ahmed Abdallah El Ashry – Kafr Shoukr**	**KAAS5 (Dust)**	ND	ND	ND	ND					

Table B.5: Analysis Results of Wipe Samples from Flour Mills

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
1	El Hazania – Shebeen El Anater	HZ-W1 (Wipe)	Not Reported								
		HZ-W2 (Wipe)	Not Reported								
		HZ-W3 (Wipe)	Not Reported								
		HZ-W4 (Wipe)	Not Reported								
		HZ-W5 (Wipe)	Not Reported								
		HZ-W6 (Wipe)	Not Reported								
		HZ-W7 (Wipe)	Not Reported								
		HZ-W8 (Wipe)	Not Reported								
2	Rizk Mahmoud Hassan- Noot Taha- Shebeen El Anater	NT-W1 (Wipe)	ND	ND	ND	ND					
		NT-W2 (Wipe)	0.010	ND	ND	ND					
		NT-W3 (Wipe)	ND	ND	ND	ND					
		NT-W4 (Wipe)	ND	ND	ND	ND					
		NT-W5 (Wipe)	ND	ND	ND	ND					
		NT-W6 (Wipe)	0.020	ND	ND	ND					
		NT-W7 (Wipe)	ND	ND	ND	ND					

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
3	Hanna Saad Habib Kashesh Shebeen El Kanater	KSH-W1 (Wipe)	ND	ND	ND	ND					
		KSH-W2 (Wipe)	0.01	0.03	ND	ND					
		KSH-W3 (Wipe)	ND	ND	ND	ND					
		KSH-W4 (Wipe)	ND	ND	ND	ND					
		KSH-W5 (Wipe)	ND	ND	ND	ND					
		KSH-W6 (Wipe)	ND	ND	ND	ND					
		KSH-W7 (Wipe)	ND	ND	ND	ND					
		KSH-W8 (Wipe)	ND	ND	ND	ND					
4	Badawy Bayoumi El Manayel – El khanka	MEk-W1 (Wipe)	Not Reported								
		MEK-W2 (Wipe)	Not Reported								
		MEK-W3 (Wipe)	Not Reported								
		MEK-W4 (Wipe)	Not Reported								
5	Kafr Ebian-Khanka	KA-W1 (Wipe)	0.096	ND	ND	ND					
		KA-W3 (Wipe)	0.15	ND	ND	ND					
		KA-W4 (Wipe)	0.072	ND	ND	ND					

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
		KA-W5 (Wipe)	0.16	ND	ND	ND					
		KA-W6 (Wipe)	0.09	ND	ND	ND					
6	Hassan Abdel Kareem Belquas Qalyoub	B1-W1 (Wipe)	ND	ND	ND	ND					
		B2-W2 (Wipe)	ND	ND	ND	ND					
		B3-W3 (Wipe)	0.011	ND	ND	ND					
		B4-W4 (Wipe)	ND	ND	ND	ND					
		B5-W5 (Wipe)	0.013	ND	ND	ND					
		B6-W6 (Wipe)	ND	ND	ND	ND					
7	Mohamed Shadad- Tanan Qalyoub	M1-W1 (Wipe)	0.021	ND	ND	ND					
		M1-W2 (Wipe)	0.26	ND	ND	ND					
		M1-W3 (Wipe)	0.194	ND	ND	ND					
		M1-W4 (Wipe)	0.020	ND	ND	ND					
		M1-W5 (Wipe)	0.070	ND	ND	ND					
		M1-W6 (Wipe)	0.019	ND	ND	ND					
		M1-W7 (Wipe)	0.210	ND	ND	ND					

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
8	Abdallah Shadad-Tanan Qalyoub	T-W1 (Wipe)	ND	ND	ND	ND					
		T-W2 (Wipe)	ND	ND	ND	ND					
		T-W3 (Wipe)	0.012	ND	ND	ND					
		T-W4 (Wipe)	ND	ND	ND	ND					
9	Abdel Monsef Noor El Deen-Koom Ashfeen-Qalyoub	K-W1 (Wipe)	0.017	ND	ND	ND					
		K-W2 (Wipe)	0.024	ND	ND	ND					
		K-W3 (Wipe)	0.011	ND	ND	ND					
		K-W4 (Wipe)	0.2	ND	ND	ND					
10	Aida Tekla Gerges – Al Munirah	MT-W1 (Wipe)	ND	ND	ND	ND					
		MT-W2 (Wipe)	0.01	ND	ND	ND					
		MT-W3 (Wipe)	0.1	ND	ND	ND					
		MT-W4 (Wipe)	ND	ND	ND	ND					
		MT-W5 (Wipe)	ND	ND	ND	ND					
		MT-W6 (Wipe)	ND	ND	ND	ND					
11	Adel Mekkawy Shoubra Shehab	SH-W1 (Wipe)	ND	ND	ND	ND					

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
		SH-W2 (Wipe)	ND	ND	ND	ND					
		SH-W3 (Wipe)	ND	ND	ND	ND					
12	Summer El-Shafey-Mansheyat Abu El Gheit, El Kanater	G-W1 (Wipe)	Not Reported								
		G-W2 (Wipe)	Not Reported								
		G-W3 (Wipe)	Not Reported								
		G-W4 (Wipe)	Not Reported								
		G-W5 (Wipe)	Not Reported								
		G-W6 (Wipe)	Not Reported								
13	Eid Negm Eid—Kafr El Shourafa Kanater	EK-W1 (Wipe)	0.02	ND	ND	ND					
		EK-W2 (Wipe)	ND	ND	ND	ND					
		EK-W3 (Wipe)	ND	ND	ND	ND					
		EK-W4 (Wipe)	ND	ND	ND	ND					
		EK-W5 (Wipe)	ND	ND	ND	ND					
14	Abdallah Saleh - Toukh	TAM-W1 (Wipe)	ND	ND	ND	ND					
		TAM-W2 (Wipe)	ND	ND	ND	ND					

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
		TAM-W3 (Wipe)	ND	ND	ND	ND					
15	Adel Omar – Mushtoher - Toukh	MUTA-W1 (Wipe)	ND	ND	ND	ND					
		MUTA-W2 (Wipe)	ND	ND	ND	ND					
		MUTA-W3 (Wipe)	ND	ND	ND	ND					
16	Abdul Hameed Eid – Hafr El Arab - Banha	KEAB-W1 (Wipe)	ND	ND	ND	ND					
		KEAB-W2 (Wipe)	ND	ND	ND	ND					
		KEAB-W3 (Wipe)	ND	ND	ND	ND					
17	Abdul Samee' Ismaeil Salam - Kafr Atallah - Banha	KAB-W1 (Wipe)	ND	ND	ND	ND					
		KAB-W2 (Wipe)	ND	ND	ND	ND					
		KAB-W3 (Wipe)	ND	ND	ND	ND					
18	Al-Sayed Ghareeb –Kafr Abu Zekri	ZB-W1 (Wipe)	ND	ND	ND	ND					
		ZB-W2 (Wipe)	ND	ND	ND	ND					
		ZB-W3 (Wipe)	ND	ND	ND	ND					
		MBS-W1 (Wipe)	ND	ND	ND	ND					

Mill ID No.	Mill Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
19	Samir Awad – Meit El Attar – Banha	MBS-W2 (Wipe)	ND	ND	ND	ND					
		MBS-W3 (Wipe)	ND	ND	ND	ND					
		MBS-W4 (Wipe)	ND	ND	ND	ND					
		MBS-W5 (Wipe)	ND	ND	ND	ND					
		MBS-W6 (Wipe)	ND	ND	ND	ND					
20	Ahmed Abdallah El Ashry – Kafr Shoukr	KAAS-W1 (Wipe)	ND	ND	ND	ND					
		KAAS-W2 (Wipe)	ND	ND	ND	ND					

Table B.6: Analysis Results of Soil Samples from Selected Agricultural Fields

Field ID No.	Field Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
1	Balqas	B1 (Surface Soil)	0.010	ND	ND	ND		BDl			
		B2 (Root Zone Soil)	ND	ND	ND	ND					
		B3 (Surface Soil)	ND	ND	ND	ND					
		B4 (Root Zone Soil)	0.020	ND	ND	ND					
		B5 (Surface Soil)	ND	ND	ND	ND					
		B6 (Root Zone Soil)	ND	ND	ND	ND		BDL			
		B7 (Surface Soil)	0.002	ND	ND	ND					
		B8 (Root Zone Soil)	0.002	ND	ND	ND					
		B9 (Surface Soil)	0.004	ND	ND	ND					
		B10 (Root Zone Soil)	0.003	ND	ND	ND					
		B11 (Surface Soil)	0.004	ND	ND	ND		3.0869			
		B12 (Root Zone Soil)	0.005	ND	ND	ND					
		B13 (Surface Soil)	0.003	ND	ND	ND					
		B14 (Root Zone Soil)	0.010	ND	ND	ND					
		B15 (Surface Soil)	0.003	ND	ND	ND					
		B16	0.004	ND	ND	ND		1.982			

Field ID No.	Field Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
		(Root Zone Soil)									
2	Tanan	T1 (Surface Soil)	ND	ND	ND	ND					
		T2 (Root Zone Soil)	ND	ND	ND	ND					
		T3 (Surface Soil)	ND	ND	ND	ND					
		T4 (Root Zone Soil)	ND	ND	ND	ND					
		T5 (Surface Soil)	ND	ND	ND	ND		0.299			
		T6 (Root Zone Soil)	ND	ND	ND	ND					
		T7 (Surface Soil)	ND	ND	ND	ND					
		T8 (Root Zone Soil)	ND	ND	ND	ND					
		T9 (Surface Soil)	ND	ND	ND	ND					
		T10 (Root Zone Soil)	ND	ND	ND	ND		BDL			
		T11 (Surface Soil)	ND	ND	ND	ND					
		T12 (Root Zone Soil)	ND	ND	ND	ND					
		T13 (Surface Soil)	ND	ND	ND	ND					
		T14 (Root Zone Soil)	ND	ND	ND	ND					
		T15 (Surface Soil)	ND	ND	ND	ND					
		T16 (Root Zone Soil)	ND	ND	ND	ND		BDL			

Field ID No.	Field Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
3	Shoubra Shehab	P1 (Bulk Soil)	0.002	ND	ND	ND					
		P2 (Bulk Soil)	0.003	ND	ND	ND					
		P3 (Bulk Soil)	0.004	ND	ND	ND					
		P4 (Bulk Soil)	0.002	ND	ND	ND					
		P5 (Bulk Soil)	0.004	ND	ND	ND					
		P6 (Bulk Soil)	0.004	ND	ND	ND					
		P7 (Bulk Soil)	0.003	ND	ND	ND					
		P8 (Bulk Soil)	0.004	ND	ND	ND					
		P9 (Bulk Soil)	0.004	ND	ND	ND					
		P10 (Bulk Soil)	0.003	ND	ND	ND					
		P11 (Bulk Soil)	0.002	ND	ND	ND					
		P12 (Bulk Soil)	0.004	ND	ND	ND					
		P13 (Bulk Soil)	0.002	ND	ND	ND					
		P14 (Bulk Soil)	0.003	ND	ND	ND					
		P15 (Bulk Soil)	0.003	ND	ND	ND					
		P16 (Bulk Soil)	0.003	ND	ND	ND					

Field ID No.	Field Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
4	Abu El Gheit	A1 (Surface Soil)	0.003	ND	ND	ND		BDL			
		A2 (Root Zone Soil)	0.003	ND	ND	ND					
		A3 (Surface Soil)	0.004	ND	ND	ND					
		A4 (Root Zone Soil)	0.004	ND	ND	ND					
		A5 (Surface Soil)	0.002	ND	ND	ND		BDL			
		A6 (Root Zone Soil)	0.004	ND	ND	ND					
		A7 (Surface Soil)	0.005	ND	ND	ND					
		A8 (Root Zone Soil)	0.003	ND	ND	ND					
		A9 (Surface Soil)	0.004	ND	ND	ND					
		A10 (Root Zone Soil)	0.005	ND	ND	ND		BDL			
		A11 (Surface Soil)	0.003	ND	ND	ND					
		A12 (Root Zone Soil)	0.002	ND	ND	ND					
		A13 (Surface Soil)	0.004	ND	ND	ND					
		A14 (Root Zone Soil)	0.002	ND	ND	ND					
		A15 (Surface Soil)	0.003	ND	ND	ND		BDL			
		A16 (Root Zone Soil)	0.006	ND	ND	ND					
5	Emiai, Toukh	TO1	0.0024	ND	ND	ND					

Field ID No.	Field Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
		(Surface Soil)									
		TO2 (Root Zone Soil)	0.0019	ND	ND	ND					
		TO3 (Surface Soil)	0.0023	ND	ND	ND					
		TO4 (Root Zone Soil)	0.0045	ND	ND	ND					
		TO5 (Bulk Soil)	0.0016	0.05	ND	ND					
		TO6 (Bulk Soil)	0.0015	ND	ND	ND					
		TOW1 (Wipe)	0.0006	ND	ND	ND					
		TOW2 (Wipe)	ND	ND	ND	ND					
		TOW3 (Wipe)	ND	ND	ND	ND					
6	Kafr El Arab, Banha	BSS1 (Bulk Soil)	0.006	0.046	ND	ND					
		BSS2 (Bulk Soil)	0.005	0.062	ND	ND					
		BSS3 (Bulk Soil)	0.004	0.038	ND	ND					
		BSS4 (Bulk Soil)	0.003	0.019	ND	ND					
		BSS5 (Bulk Soil)	ND	ND	ND	ND					
		BSS6 (Bulk Soil)	0.003	0.103	ND	ND					
		BSS7 (Bulk Soil)	0.005	0.036	ND	ND					
		BSS8 (Bulk Soil)	0.004	0.058	ND	ND					

Field ID No.	Field Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
		BSS9 (Bulk Soil)	0.007	ND	ND	ND					
		BSS10 (Bulk Soil)	0.002	ND	ND	ND					
7	Kafr Shoukr	KFSS1 (Bulk Soil)	0.006	0.092	ND	ND					
		KFSS2 (Bulk Soil)	0.007	0.098	ND	ND					
		KFSS3 (Bulk Soil)	0.003	ND	ND	ND					
		KFSS4 (Bulk Soil)	0.004	0.055	ND	ND					
		KFSS5 (Bulk Soil)	0.005	0.010	ND	ND					
		KFSS6 (Bulk Soil)	0.004	ND	ND	ND					
		KFSS7 (Bulk Soil)	0.003	0.031	ND	ND					
		KFSS8 (Bulk Soil)	0.003	0.092	ND	ND					
		KFSS9 (Bulk Soil)	0.004	0.015	ND	ND					
		KFSS10 (Bulk Soil)	0.004	0.061	ND	ND					
Limit of Heavy Metal in Soil(mg/kg)			70	----------	-------						

Table B.7: Analysis Results of Wipe Samples from Agricultural Fields

Field ID No.	Field Name	Cairo University Lab Results				
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm
1	Balqas	BW1 (Wipe)	ND	ND	ND	ND
		BW2 (Wipe)	ND	ND	ND	ND
		BW3 (Wipe)	ND	ND	ND	ND
		BW4 (Wipe)	ND	ND	ND	ND
		BW5 (Wipe)	ND	ND	ND	ND
		BW6 (Wipe)	ND	ND	ND	ND
		BW7 (Wipe)	ND	ND	ND	ND
		BW8 (Wipe)	ND	ND	ND	ND
2	Tanan	TW1 (Wipe)	ND	ND	ND	ND
		TW2 (Wipe)	ND	ND	ND	ND
		TW3 (Wipe)	ND	ND	ND	ND
		TW4 (Wipe)	ND	ND	ND	ND
		TW5 (Wipe)	ND	ND	ND	ND
		TW6 (Wipe)	ND	ND	ND	ND
		TW7 (Wipe)	ND	ND	ND	ND
		TW8 (Wipe)	ND	ND	ND	ND
3	Shoubra Shehab	PW1 (Wipe)	ND	ND	ND	ND
		PW2 (Wipe)	ND	ND	ND	ND
		PW3 (Wipe)	ND	ND	ND	ND
		PW4 (Wipe)	ND	ND	ND	ND
		PW5 (Wipe)	ND	ND	ND	ND
		PW6 (Wipe)	ND	ND	ND	ND
		PW7 (Wipe)	ND	ND	ND	ND
		PW8 (Wipe)	ND	ND	ND	ND
4	Abu El Gheit	AW1 (Wipe)	ND	ND	ND	ND

Field ID No.	Field Name	Cairo University Lab Results				
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm
		AW2 (Wipe)	ND	ND	ND	ND
		AW3 (Wipe)	ND	ND	ND	ND
		AW4 (Wipe)	ND	ND	ND	ND
		AW5 (Wipe)	ND	ND	ND	ND
		AW6 (Wipe)	ND	ND	ND	ND
		AW7 (Wipe)	ND	ND	ND	ND
		AW8 (Wipe)	ND	ND	ND	ND
5	Emiai, Toukh	TOW1 (Wipe)	0.0006	ND	ND	ND
		TOW2 (Wipe)	ND	ND	ND	ND
		TOW3 (Wipe)	ND	ND	ND	ND
6	Kafr El Arab, Banha	BSSW1 (Wipe)	ND	ND	ND	ND
		BSSW2 (Wipe)	ND	ND	ND	ND
		BSSW3 (Wipe)	ND	ND	ND	ND
		BSSW4 (Wipe)	ND	ND	ND	ND
		BSSW5 (Wipe)	ND	ND	ND	ND
7	Kafr Shoukr	KFSSW1 (Wipe)	ND	ND	ND	ND
		KFSSW2 (Wipe)	ND	ND	ND	ND
		KFSSW3 (Wipe)	ND	ND	ND	ND
		KFSSW4 (Wipe)	ND	ND	ND	ND
		KFSSW5 (Wipe)	ND	ND	ND	ND

Table B.8: Analysis Results of Irrigation Water Samples from Selected Agricultural Fields

Field ID No.	Field Name	Cairo University Lab Results						Cross Reference Samples			
		Sample Code & Description	Pb ppm	Cd ppm	As ppm	Hg ppm		Pb ppm	Cd ppm	As ppm	Hg ppm
1	Balqqas	Irrigation Water 1	0.009	-	0.001	-		ND	-	-	-
		Irrigation Water 2	0.024	-	0.016	-		ND	-	-	-
2	Tanan	Irrigation Water 1	0.058	-	0.015	-		ND	-	-	-
		Irrigation Water 2	0.016	-	0.008	-		ND	-	-	-
3	Shoubra Shehab	Irrigation Water 1	0.003	0.163	ND	ND		ND	-	-	-
		Irrigation Water 2	0.005	0.112	ND	ND		ND	-	-	-
4	Abu El Gheit	Irrigation Water 1	0.015	0.103	ND	ND		ND	-	-	-
		Irrigation Water 2	0.002	0.038	ND	ND		ND	-	-	-
5	Emiai, Toukh	Irrigation Water 1	ND	ND	ND	ND		ND	-	-	-
6	Kafr El Arab, Banha	Irrigation Water 1	0.004	ND	ND	ND		ND	-	-	-
7	Kafr Shoukr	Irrigation Water 1	0.001	ND	ND	ND		ND	-	-	-
	Limit		0.05 mg/L	----------	-------	-------					

APPENDIX C: LABORATORY QA/QC PROCEDURES

APPENDIX D: ASSESSMENT OF ANALYTICAL DATA QUALITY

This appendix presents an assessment of analytical data quality for metallic contaminants in grain, flour, dust, wipes, soil, and water samples collected from the twenty flour mills located in Qalyoubia. Internal laboratory calibration, duplicate sample analyses, laboratory accuracy, laboratory precision and sampling precision are discussed. In addition, sample custody and holding times were reviewed as qualitative indicators of data quality and usability.

Grain, flour, dust, wipe, soil, and water samples were collected in sterile containers provided by the LIFE-Lead Project. Sample containers were sealed, labeled with unique sample identification numbers, and transported in a cooler on ice to the Cairo University Center for Environmental Hazard Mitigation. Field samples were delivered in good condition, within the method holding time (180 days) for metals analyses. No transcription errors or inconsistencies between sample custody documentation and laboratory reports were noted.

Instrument Calibration

Initial and daily instrument calibration using calibration standards and blanks indicate a recovery range of 97 percent to 103 percent. Percent recoveries in the range of 90 percent to 110 percent are considered acceptable for initial and continuing calibration verification.[1] Therefore, instrument calibration is considered acceptable.

Precision

Precision is a measure of reproducibility between laboratory duplicates and matrix spikes/matrix spike duplicates (analytical precision), and field samples and field sample duplicates (sampling precision). Precision is evaluated on the basis of Relative Percent Difference (RPD). The RPD is calculated according to the following formula:

$$\text{RPD} = \frac{|D_1 - D_2|}{(D_1 + D_2)/2} \times 100$$

where: D_1 = First Duplicate Value

D_2 = Second Duplicate Value

RPD control limits for internal duplicates are generally established by the laboratory, based on historical performance data. Laboratory control limits were not reported for samples collected from the flour mills. However, a good rule of thumb for laboratory precision is ±20 percent for sample values greater than or equal to five times the detection limit. For purpose of this data quality assessment, an acceptable RPD of ±20 percent is proposed for field duplicate samples.

Field duplicate samples are analyzed as an indication of overall precision. These analyses actually measure both field and laboratory precision; therefore, the results may have more variability than laboratory duplicates which measure only laboratory performance.[2]

[1] USEPA. 2004. Contract Laboratory Program: National Functional Guidelines for Inorganic Data Review. OSWER 9240.1-45, EPA 540-R-04-004. Office of Solid Waste and Emergency Response (OSWER), USEPA, Washington. October 2004

[2] USEPA, *op. cit.*, 2004.

Analytical results indicate that field sampling and analytical precision varied widely among field duplicate samples (Table C-1). The RPD for field duplicates of flour samples ranged from 1.56 to 13.17 percent. The RPD for dust samples was reported to be 6.90 percent. Based on these results, recoveries from field duplicates indicate sampling method is in control.

Table C-1. Summary of Field Duplicate Results

Sample Number	Type	D_1 (µg/g)	D_2 (µg/g)	$\|D_1-D_2\|$	$(D_1+D_2)/2$	$\|D_1-D_2\|/(D_1+D_2)/2 \times 100$ RPD (%)
HZ B1	flour	1.450	1.227	0.173	1.3135	13.17
HZ B3	flour	5.15	5.042	0.108	5.096	2.12
M D1	flour	2.4	2.363	0.037	2.3815	1.56
NT B4	flour	1.91	1.87	0.040	1.89	2.12
KA B2	flour	1.45	1.538	0.088	1.494	5.89
KSH B6	dust	2.533	2.714	0.181	2.6235	6.90

Accuracy

The accuracy of the analytical method is evaluated based on the measurement or recovery of a known concentration of analyte (spike) introduced into a quality control sample. The percent recovery for a spiked sample is calculated according to the following formula:

$$\text{Percent Recovery} = \frac{\text{Spiked Sample Result} - \text{Unspiked Sample Result}}{\text{Spike Concentration}} \times 100$$

Laboratory control limits were not reported for spike recoveries. Although spike recoveries are expected to vary with the individual analyte being analyzed, spike recoveries in the range of 75 percent to 125 percent are generally acceptable for metals analyses.[3] Spike recoveries for lead in soil and dust samples ranged from 96.9 percent to 104.6 percent, indicating an acceptable level of accuracy for these analyses (Table C-2). Recovery results indicate that the analytical method is in control.

Table C-2. Summary of Spike Recovery Results

Analyte	Matrix	Sample Identification	Spiked Result (µg/ml)	Unspiked Result (µg/ml)	Recovery (µg/ml)	Spike Conc. (µg/ml)	Percent Recovery
Pb	flour	HZ B1	1.79	1.4	0.39	0.392	99.5
	flour	HZ B3	5.56	5.15	0.41	0.392	104.6
	flour	MD 1	2.78	2.4	0.38	0.392	96.9
	flour	NTB4	2.29	1.91	0.38	0.392	96.9
	flour	KA B2	1.85	1.45	0.4	0.392	102.0
	dust	KSH B6	2.94	2.533	0.407	0.392	103.8

[3] USEPA, *op. cit.*, 2004.

Representativeness

Representativeness is a qualitative parameter that expresses the degree to which sample data accurately and precisely represent a characteristic of a population, a sampling point, or an environmental condition. Representativeness is largely dependent on the design and execution of the sampling plan. Representativeness is maximized by ensuring that, for a given project, the number and location of sampling points and the sample collection and analysis techniques are appropriate for the specific investigation and that the sampling and analysis program will provide information that reflects "true" site conditions.

To assure representative sampling at the flour mills, a Sampling and Analysis Plan (SAP) was developed by the LIFE-LEAD Project to evaluate the extent and source of metal contamination in flour. In accordance with this plan, grain samples were randomly selected from bags found at the mill. Flour samples were directly collected from the outlet of the grinding machine and flour mill sieves. Bulk dust sampling locations were randomly selected from areas of accumulated dust within the mill. Wipe samples were collected from the exposed surface of the grinding machine (e.g., the hopper) and from interior walls. Wipe samples were also collected for corn leaves from fields nearby some of the targeted flour mills. Soil and water samples were also collected from the same nearby fields. As such, the sampling design has achieved the objective of generating data that is representative of actual conditions and assists in attaining project targets.

Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set may be compared to another. Data are considered comparable when samples are analyzed according to the same standard analytical methods, reported using standard units of measure, and collected using equivalent sampling procedures. All data generated for this investigation are based on comparable sample digestion and ICP analytical methods, reported using standard units of measure (mg/kg or µg/l), and collected according to the procedures specified in the in the project Sampling and Analysis Plan. The laboratory detection limit for lead was 0.004 µg/g, cadmium was 0.0002 mg/g, mercury was 0.005 mg/g, and arsenic 0.002 mg/g which is sufficiently low for assessment purposes (at least one order of magnitude below the lowest contaminant concentration detected in any of the samples). Therefore, the analytical data generated by the laboratory for this investigation are considered comparable.

Completeness

With respect to the analytical data generated by the laboratory, completeness is defined as the ratio of valid sample measurements to the total number of measurements planned for a specific matrix and/or analysis. The percent completeness of the data was calculated according to the following equation:

$$\text{Completeness} = \frac{\text{Number of Valid Measurements}}{\text{Number of Measurements Planned}} \times 100$$

The total number of measurements planned for this investigation is the total number of metal contamination analyses requested from the laboratory. A total of 369 flour, grain, dust, wipe, soil, and water samples were submitted to the Cairo University Center for Environmental Hazard Mitigation for analysis of lead, cadmium, arsenic, and mercury (37 flour samples, 32 grain samples, 36 dust samples, 90 soil samples, 3 additive samples, 141 wipe samples, and 11 water samples). This number includes field duplicates, but does not include laboratory quality control samples. The number of valid measurements is based on the criteria for precision, accuracy, representativeness, and comparability.

Due to problems with the sample preparations, 23 samples were not analyzed. All analyzed samples met the acceptance criteria for accuracy, representativeness, and comparability. The total number of valid measurements for the data considered in this assessment is therefore: 369-23 = 346. The calculated completeness of the data is:

$$\frac{346}{369} \times 100 = 93.8\%$$

Overall Data Quality Assessment

The results of this data quality assessment indicate that the analytical results of this investigation meet the project goals for precision, accuracy, representativeness, comparability, and completeness. An overall assessment of the results, which takes into account these data quality indicators, indicates that the analytical data for samples collected from the selected flour mills are acceptable for their intended use.