T.C.

MARMARA UNIVERSITY

INSTITUTE FOR GRADUATE STUDIES IN

PURE AND APPLIED SCIENCES

DETERMINATION OF INDOOR AIR PARTICULATE MATTER MASS AND ELEMENTAL CONCENTRATIONS IN A SELECTED HOSPITAL

Selen KILIÇ

THESIS

FOR THE DEGREE OF MASTER OF SCIENCE

IN

ENVIRONMENTAL ENGINEERING

SUPERVISOR

Assoc. Prof. Dr. S. Sinan KESKİN

İSTANBUL 2010

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ACCEPTANCE AND APPROVAL DOCUMENT

The jury established by the Executive Board of the *INSTITUTE FOR GRADUATE STUDIES IN PURE AND APPLIED SCIENCES* on ..... (Resolution no:.....) has accepted Ms Selen KILIÇ's thesis titled "Determination of Indoor Air Particulate Matter Mass and Elemental Concentrations in a Selected Hospial " as Master of Science thesis in Environmental Engineering.

Advisor :

1. Member of the jury:

2. Member of the jury:

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Date : .....

APPROVAL

Ms. Selen KILIÇ has satisfactorily completed the requirements for the degree of Master of Science in Environmental Engineering at Marmara University. The Executive Commitee approves that she be granted the degree of Master of Science on…YK tarihi (Resolution no: YK karar no)

DIRECTOR OF THE INSTITUTE

Prof. Dr. Ad/Soyad

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JANUARY 2010 **Selen KILIÇ**

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ABSTRACT

DETERMINATION OF INDOOR AIR PARTICULATE MATTER MASS AND ELEMENTAL CONCENTRATIONS IN A SELECTED HOSPITAL

In this thesis study, it is intended to determine the indoor air suspended particulate matter mass and elemental concentrations in a selected hospital located in Istanbul which is the most populated city in Turkey. This study was accomplished in four stages as preparation, sampling, analysis, and evaluation. At the first stage, the necessary official permission was obtained from the Marmara University Hospital administration that has been chosen as the sampling site. At the second stage, PM_{10} and $PM_{2.5}$ particulate matter collections were performed in children's polyclinic and internal medicine stay patient's floor. At the third stage, mass concentrations and elemental concentrations were determined gravimetrically and using ICP-MS, respectively. At the final stage, the obtained data was evaluated and conclusions were made. Obtained particulate matter mass concentration values were greater than those of the European Union and the United States air quality standards limit values but within the specified limits of Turkish air quality standards. From the measured elemental concentrations, it has been concluded that mainly traffic and industrial emissions together with crustal and marine emissions are responsible for the current situation.

JANUARY 2010 **Selen KILIÇ**

ÖZET

SEÇİLEN BİR HASTANEDE İÇ ORTAM HAVASI PARTİKÜL MADDE KÜTLE ve ELEMENT KONSANTRASYONLARININ BELİRLENMESİ

Bu çalışmada, Türkiye'nin en büyük şehri olan İstanbul'da seçilen bir hastanenin iç ortam havasında bulunan asılı parçacık madde kütle konsantrasyonları ile bu parçacıklar içinde bulunan elementlerin konsantrasyonlarının belirlenmesi amaçlanmıştır. Bu çalışma hazırlık, örnekleme, analiz ve değerlendirme olmak üzere dört aşamada tamamlanmıştır. İlk aşamada, örnekleme sahası olarak seçilen Marmara Üniversitesi Hastanesi yönetiminden gerekli izinler alınmıştır. İkinci aşamada, hastane içinde belirlenen biri çocuk polikliniği, diğeri dahiliye bölümü yatan hasta katı olmak üzere iki farklı alanda PM_{10} ve $PM_{2.5}$ partikül madde örneklemeleri gerçekleştirilmiştir. Üçüncü aşamada, kütle konsantrasyonları gravimetrik yöntemle, element konsantrasyonları ICP-MS ölçümleriyle belirlenmiştir. Son aşamada ise elde edilen veriler değerlendirilmiş ve yorumlanmıştır. Çalışmada ölçülen partikül madde kütle konsantrasyon değerlerinin Avrupa Birliği ve Amerika Birleşik Devletleri hava kalite standartlarında belirtilen değerlerin üzerinde olduğu, ancak Türkiye'de geçerli standartları aşmadığı gözlenmiştir. Ölçülen element konsantrasyonlarının incelenmesinden, mevcut durumun ağırlıklı olarak trafik ve endüstriyel kaynaklı emisyonlar ile toprak ve deniz kaynaklı emisyonlardan kaynaklandığı sonucuna varılmıştır.

OCAK 2010 **Selen KILIÇ**

CLAIM FOR ORIGINALITY

DETERMINATION OF INDOOR AIR PARTICULATE MATTER MASS AND ELEMENTAL CONCENTRATIONS IN A SELECTED HOSPITAL

Indoor air quality is a significant issue in health care. Epidemiological studies published across the world have shown a strong relationship between air pollution and various kinds of health problems. Among these pollutants, particulate matter often enters the human body via the respiratory system and they may cause direct damage upon contact with respiratory tissues or indirectly affect the isolated tissues or another vulnerable organ of the body via transportation through circulatory system. Due to these reasons, it is important to determine both mass and elemental concentrations of particulate matter in indoor air environments. The aim of this study was to determine indoor air suspended particulate matter mass and elemental concentrations in a selected hospital. Considering that hospitals are crowded indoor environments serving to a high number of patients, we believe that this study will contribute to the indoor air pollution studies in our country and fill a gap for indoor air particulate matter pollution assessment in hospitals as we are not aware of a similar scientific study performed earlier.

JANUARY 2010 **Assoc. Prof. Dr. S. SİNAN KESKİN** **Selen KILIÇ**

SYMBOLS

PM0.1 **:** Particles with aerodynamic diameters ≤ 0.1 µm

PM2.5 **:** Particles with aerodynamic diameters ≤ 2.5 µm

PM10 **:** Particles with aerodynamic diameters ≤ 10 µm

Al **:** Aluminum

As **:** Arsenic

Be **:** Beryllium

Co **:** Cobalt

Cu **:** Copper

Cl **:** Chlorine

Cr **:** Chromium

Cd **:** Cadmium

Mn **:** Manganese

Mo **:** Molybdenum

Sb **:** Antimony

V **:** Vanadium

Hg **:** Mercury

Ni **:** Nickel

Mg **:** Magnesium

Zn **:** Zinc

Sn **:** Tin

Ca **:** Calcium

Fe **:** Iron

K **:** Potassium

Ba **:** Barium

Se **:** Selenium

Ni **:** Nickel

Na **:** Sodium

Pb **:** Lead

ABBREVIATIONS

USA **:** United States of America

WHO **:** World Health Organization

NAAQS **:** National Ambient Air Quality Standards

EU **:** European Union

USEPA **:** United States Environmental Protection Agency

PM **:** Particulate Matter

TSP **:** Total Suspended Particulate

RP **:** Respirable Particulate

DI **:** Di Ionize

HCl **:** Hydrochloric acid

HNO_3 **:** Nitric acid

ICP-MS **:** Inductively Coupled Plasma – Mass Spectrometry

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CHAPTER I

INTRODUCTION and AIM

Various air pollution sources exist all over the world. These pollution sources include traffic emissions, small and large scale biomass combustion, waste burning, industrial processes, long range transported air pollution, road corrosion and resuspension, car brake eruption and fugitive dusts. The amount of contribution from these sources varies with time, season, location and climate [1]. Studies show that outdoor air quality significantly affects indoor air quality in the absence of major indoor sources [2]. Therefore the state of the outdoor air quality should be known for understanding the sources of indoor air pollution.

Indoor air pollution level is an important factor in public health since people spend approximately 70 to 90 % of their time indoors [3]. Much of this time is spent on the job and air quality is an important issue related to employee morale and productivity [4]. Indoor air pollutant sources include tobacco smoking, cooking, wood or coal burning stoves, space heaters, vacuuming, dusting and sweeping [5]. Air pollution negatively affects human, animal and plant health also causes material deterioration. Epidemiological studies show that the health effects seem to be most closely related to respirable particulates with aerodynamic diameters smaller than 10 µm (PM_{10}) and to those less than 2.5 µm ($PM_{2.5}$) [6]. These PM pollutants enter the human body via the respiratory system. This intrusion of foreign material may cause damage directly upon contact with respiratory tissues or the pollutant may be transported by the circulatory system to another sensitive organ of the body. Many epidemiological studies show that respirable particulates play a role in adverse respiratory symptoms and have significant associations with decline in lung function deaths due to respiratory and cardiovascular diseases [7, 8].

In this study, particulate matter mass and elemental concentration levels in indoor air environments of Marmara University Hospital have been searched. Indoor air quality is an important factor in the overall health atmosphere in hospitals. The indoor air quality in a hospital can influence the health of both patients and hospital staff who attend them [9]. The patient population in a hospital is largely drawn from just the very young, the elderly of people. In most cases they spend 100 % of their time in an indoor environment [10]. Although there are many examples related to indoor air particulate matter research in European countries, the USA and China [5, 11, 12], we are not aware of a similar study for indoor air PM pollutants in hospitals in Turkey within the scientific literature. We believe that this study will contribute to the understanding of indoor air particulate pollution levels and the associated risks for public health.

CHAPTER II

GENERAL INFORMATION

II.1. LAWS and HISTORY

In general, laws and regulations follow public air quality concerns due to increasing pollution levels. Restrictions are used to protect health and safety of the public. Another approach has been to allow for lawsuits as a result of public nuisance complaints. In general, public nuisance complaints have been among the oldest legal approaches used to decrease air pollution emissions [13].

The U.S. Environmental Protection Agency (EPA) was established in 1970 and the focus of air quality control authorities has been increasingly federalized. The EPA has nationwide authority in all areas of air quality management in addition to setting air quality standards and maximum levels of emissions [14, 15].

In U.S., each state has specific authority to implement its own air quality management program. Enabling legislation at the state level is required in order to set up a statewide program. To enforce federal laws, state legislation must be adopted and approved by the EPA to give federal enforcement authority to the state. Otherwise, the federal government is the enforcing authority. Before 1987, EPA's standards regulated all particles (so called "total suspended particulates"), including those larger than 10 micrometers. In 1987, US National Ambient Air Quality Standards (NAAQS) were revised since research had shown that the particles of greatest health concern were those equal to or less than 10 micrometers that can penetrate into sensitive regions of the respiratory tract [16].

The World Health Organization (WHO) has reviewed a document on air pollution and health and suggested guidelines that it regarded would sufficiently protect public health [17]. The most frequently used reference guidelines for ambient particulate concentration are those of WHO, the EU and the USEPA. These

guidelines are based on clinical, toxicological, and epidemiological evidence and were established by determining the concentrations with the lowest observed adverse effect, so using subject from animals to humans and from small groups of humans to larger populations [18].

In Turkey, environmental problems were first stated in 1982. Constitution and legal definitions were included in Environmental Law 2872 in August 9, 1983. The respective Environmental Law had the characteristics of a framework law, consisting of 6 chapters and 34 articles, leaving some applications in different fields to the regulations. "Regulation of the protection of air quality", which is one of these regulations, has entered into force in 1986. This regulation approached the solution of the air pollution problem with emission control. Thus, it is required for each plant to declare its pollutant characteristics regarding to its production variety and size. The official administration archives these declarations and monitors them. The limit values of air quality parameters in Turkey are given by the "regulation of the protection of air quality document". These limit values of PM_{10} are 150 $\mu g/m^3$ (annual mean) and 300 $\mu g/m^3$ (24 hour mean), for general areas while they are 200 $\mu g/m^3$ (annual mean) and 400 $\mu g/m^3$ (24 hour mean) for industrial areas [19, 20].

II.2. PARTICULATE MATTER

A major class of air pollution sources generates particulate matter (PM). PM can be either liquid droplets or solid dusts and comes in physical and chemical properties with a wide range of variety of forms and sizes [21]. Ambient levels of mass concentration are measured in micrograms per cubic meter ($\mu g/m^3$) and size attributes are usually measured in aerodynamic diameter [18].

Respirable particulates are those with aerodynamic diameter smaller than 10 µm (PM_{10}) and they are easily breathed in and deposited within the respiratory system. The size distribution of total suspended particles (TSPs) in the ambient air is trimodal in general, including coarse particles, fine particles and ultrafine particles. They are particles with aerodynamic diameter less than or equal to 10 µm (PM_{10}), 2.5µm ($PM_{2.5}$), and to 0.1µm ($PM_{0.1}$), respectively [12, 21, 22]. Coarse particles typically include organic material, silicates and larger soot aggregates [12]. Some particulates come from natural sources such as evaporated sea spray, mold, windborne pollen, dust and volcanic or other geothermal eruptions and they tend to be coarse [23]. Fine particles generally include a mixture of particles resulting from

different kinds of combustion processes, including fossil fuel burning for steam generation, heating and household cooking, agricultural field burning, diesel-fueled engine combustion and various industrial processes and the other particulates generated by chemical reactions in the atmosphere such as acid condensates, sulfates and nitrates [12, 24]. Ultrafine particles come mainly from combustion-related sources, such as vehicle exhaust emissions and atmospheric photochemical reactions [21].

The existence of hazardous materials including biological, chemical, and physical agents such as carbon dioxide, carbon monoxide, sulphur dioxide, nitrogen oxides, radon, volatile organic compounds, microorganisms in houses and the other non-industrialized buildings have been defined as “indoor air pollution” [1]. Respirable particulates can travel from 40 km to 805 km. Studies show that outdoor air quality significantly affects indoor air quality and in general, intake of outdoor air constitutes the main source of pollutants in the indoor environment [2]. Almost 80 % Turkish population live in the urban areas and people in these areas spend approximately 90 % of their time in the closed environments. Therefore, health problems could increase due to indoor air pollution in these areas [1].

Epidemiological studies show that various kinds of health problems are associated with particulate air pollution [6]. RP play a role in the occurrence and severity of respiratory diseases and have significant associations with decline in lung function, deaths due to respiratory and cardiovascular diseases. In recent years, public attention has been focused on fine particulates among the RP due to more adverse health effects. $PM_{2.5}$, the fine fraction in respirable particulates, is significantly correlated with deaths from cardiopulmonary disease and lung cancer. These finer particles are also the potential allergen carriers, which are probably liable to affect respiratory health, as they are able to pass deep into the respiratory system. For this reason, these fine particles seemed to be more harmful to humans than the coarse ones [12].

II.3. LIMIT VALUES

There are different standards implemented by different countries. Some examples are presented in Table II.1 below.

Table II.1 Selected $PM_{2.5}$ and PM_{10} standards

	Year	$PM_{2.5}$ (24hour mean)	$PM_{2.5}$ (annual mean)	PM_{10} (24hour mean)	PM_{10} (annual mean)
WHO	2005	25	10	50	25
USEPA	2007	35	15	150	-
Turkish Standard	1983	-	-	300	150
India Standard	1994	-	-	100	60

II.4. SOURCE ESTIMATES

Trace elements are arisen out of natural emissions and human activities. Particulates are emitted from different sources, including both combustion and noncombustion processes in industry, mining and building activities, motor vehicles and trash incineration. Natural emission sources include volcanoes, forest fires, windstorms, pollen and oceans spray. Generally, PM_{10} originates from crushing and grinding rocks and soil, blown by wind while $PM_{2.5}$ comes mainly from driving automobiles, burning plants, smelting and processing metals.

Fossil fuels are nonrenewable resources such as coal, oil and natural gas, generating the large portion of the heat energy used. The combustion of fossil fuels constitutes an anthropogenic source for Be, Co, Hg, Mo, Ni, Sb, Se, Sn and V and high percentages of As, Cd, Cu, Ni and Zn are emitted from industrial metallurgical processes. Groupings of elements are possible from the oil combustion (Cl, Se, Zn, Ni and V) and coal combustion (K, Mn, Cd, Cr, As, K, Zn) for space heating and their increase are generally associated with residential heating [25, 26, 27].

In developing countries, number of motor vehicles has been increasing in parallel to increasing urbanization resulting an increase of harmful pollutants including PM. Variable quantities of Pb, Cu, Zn, Ni and Cd are contained in exhaust emissions from gasoline. Br is emitted from non-catalytic exhausts. Zn, Cu, Pb are likely to be associated with car tires and Sb from break abrasion [28, 29, 30].

Barium is present as a trace element in both igneous and sedimentary rocks. Although it is not found free in nature, barium occurs in a number of compounds, most commonly barite ($BaSO_4$) and, to a lesser extent, witherite ($BaCO_3$). Barium compounds have a wide variety of industrial applications. They are used in the plastics, rubber, electronics and textiles industries [31]. Ca arises from cement manufacturing, iron and steel manufacturing, source power generation [32].

Marine aerosols show high fraction of Na, Cl [33]. Elements Zn and Mn closely connected with Al and Fe represents road dust [25].

II.5. HEALTH EFFECTS

Ambient particulate matter has been associated with serious health problems for many years. PM includes a mixture of several components such as carbon containing combustion particles, secondary inorganic particles, and crustal derived particles. These components may contribute with different potential, to the PM induced health problems. On the other hand, air quality standards are based on the total mass of suspended particles [1].

Many people spend most of their time indoors and indoor air pollution is the most important factor for their health. Indoor pollutant levels are variable and some studies indicate that they may be different from outdoor levels. The relationship between outdoor and indoor concentrations is hard to generalize, because it depends on local characteristics, including building construction, building age, ventilation, and existence of indoor sources [6, 34].

Airborne particles can be deposited in the respiratory tract by five mechanisms [35]:

1.Sedimentation: It represents deposition caused by gravity.

2.Impaction: When the aerodynamic diameter is larger than 1 µm, inhaled particles can deposit in the nose, pharynx, and mouth.

3.Brownian Diffusion: For particles with an aerodynamic diameter less than 1µm, Brownian diffusion is a major way for deposition in airways

4.Interception: Particle deposition in the respiratory tract can occur when the edge of the particle contacts the airway wall.

5.Electrostatic precipitation: Charged particles are attracted towards the airway walls by the electrostatic image charges they induce in the airway surface.

According to recent studies, exposure to fine particles is related with thousands of hospital admissions each year. Many of them are generally elderly people suffering from lung or heart disease. Tens of thousands of elderly people die prematurely each year from exposure to ambient fine particles.

According to the USEPA, short term exposure to coarse particulate matter can lead to coughing, difficult or painful breathing, minor throat irritation, and a reduction in lung function. Long term exposure to particulate matter may increase cardiovascular and respiratory symptoms and reduce life span [36, 37].

II.5.1. Respiratory Diseases

Respirable particulates (RP) with aerodynamic diameter smaller than 10 µm has received considerable attention in recent years as it is easily inhaled and especially fine particles can accumulate in the respiratory system which penetrate deep into the lung [7, 38]. PM has been reported associated with symptoms of asthma and increasing emergency department visits and hospitalizations for asthma [39].

Among the acute health impacts of elevated concentrations of fine particulates are increase in mortality rates, increased incidences of asthma and bronchitis and increased rates of infection in the respiratory system. They also directly irritate the respiratory tract, constrict airways and interfere with the mucus lining of the lung passages. Acute effects tend to act directly on a specific target organ or point of entry into the human body. Burns and asphyxiation are other examples of acute health effects. It is possible for a contaminant to have an acute effect which is different from its chronic effect [13].

Chronic effects are those which refer to time functions of exposure. Thus, there may be a long term exposure or a long period between an exposure and the resultant health effect. Chronic bronchitis is a chronic inflammation of the bronchi in the lungs. Asthma is an increasingly common chronic disease among children and adults. It causes shortness of breath, coughing or wheezing or whistling in the chest, sore throat. Among the chronic effects of fine particulates are losses of lung capacity and lung damage due to scarring when fine particulates are not cleared from the lung passages or alveoli. Lung cancer is the most common cause of death due to cancer. The symptoms of lung cancer begin silently and then progress to chronic cough,

breathless and chest pain. Air pollution has been linked somewhat weakly to lung cancer.

II.5.2. Cardiovascular Diseases

Increased numbers of mortality and morbidity due to cardiovascular problems have been found to be associated with elevated levels of particulate matter air pollution. Particulate matter might cause cardiac rhythm and heart rate variability in the elderly [11, 40, 41]. Studies show that, long term exposure to fine particulate matter is an important risk factor for cardiopulmonary mortality in many metropolitan areas [42]. A large number of studies published examined association of PM exposures with cardiovascular disease-related hospital admissions and deaths, yet it is practically impossible to correlate cause and effect at present because little is known regarding the characteristics of particulate matter that might contribute to this association [10, 41].

II.5.3. Effects to Children

Children are more vulnerable to the adverse effects of air pollution than are adults because the typical adult breathes 13000 liters of air per day; children breathe 50 percent more air per pound of body weight than adults. As children's respiratory systems are still developing and the developing fetal lung, as well as the infant lung, is more susceptible to injury by lung toxicants. In children, particulate pollution affects lung function and lung growth. Air pollutant doses that have no effect for adults may affect children. Exposure to fine particles is associated with increased frequency of childhood illnesses, which are of concern both in the short run and for the future development of healthy lungs in the affected children [43].

The child’s respiratory system is a primary target for air pollutants. Increased respiratory tract complications in children such as wheezing, chronic productive cough, and asthma hospitalizations have been associated with residence near areas of high traffic density [43]. They cause a wide range of acute and chronic effects. Fine particles are also associated with increased respiratory symptoms and reduced lung function in children, including symptoms such as aggravated coughing and difficulty or pain in breathing. These can result in school absences and limitations in normal childhood activities. Detoxification systems exhibit a time dependent pattern during pre- and postnatal lung development that in part accounts for the increased

susceptibility of young children to pollutants with critical points when susceptibility is higher than at other times. Research has shown that groups such as children, the elderly and people with asthma, chronic bronchitis and heart disease are especially vulnerable to particulate matter air pollution.

Table II.2 Levels of fine and coarse particulate air pollution in units of micrograms per cubic meter ($\mu g/m^3$) (USEPA, 1999)

Category	Good	Moderate	Unhealthy for sensitive groups	Unhealthy	Very Unhealthy	Hazardous	
Index Value	0-50	51-100	101-150	151-200	201-300	301-400	401-500
$PM_{2.5}$ (μgm^{-3})	0-15.4	15.5-40.4	40.5-65.4	65.5-150.4	150.5-250.4	250.5-350.4	350.5-500.4
PM_{10} (μgm^{-3})	0-54	55-154	155-254	255-354	355-424	425-504	505-604

Table II.3 Air Quality Guide [44]

Index Value	Levels of health concern	
0-50	Good	None
51-100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion
101-150	Unhealthy for sensitive groups	People with heart or lung disease , older adults and children should reduce prolonged or heavy exertion
151-200	Unhealthy	People with heart or lung disease, older adults and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion
201-300	Very Unhealthy	People with heart or lung disease, older adults and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion
301-500	Hazardous	People with heart or lung disease, older adults and children should remain indoors and keep activity levels low. Everyone else should avoid all physical activity outdoors

Good: Air quality is considered satisfactory and air pollution poses little or no risk

Moderate: Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people

Unhealthy for sensitive groups: They are likely to be affected at lower levels then the general public.

Unhealthy: Members of sensitive groups may experience more serious health effects

Very Unhealthy: Everyone may experience more serious health effects.

Hazardous: Index values over 300 trigger health warnings of emergency conditions. The entire population is more likely to be affected.

CHAPTER III

STUDIES

This thesis study intends to contribute to the understanding of indoor air particulate matter pollution levels in a university hospital. The study was accomplished in four stages: Preparation, Sampling, Analysis and Evaluation. At the first stage, the necessary official permission was obtained from the hospital administration and preparations for sampling equipment were completed. At the second stage, collections of PM on filter media were completed according to a certain sampling plan. At the third stage, analyses of PM were performed for mass and elemental concentrations. At the final stage, all data were evaluated.

Table III.1 Thesis Study Plan

MONTH	Aug 08	Sep 08	Oc 08	Nov 08	Dec 08	Jan 09	Feb 09	Mar 09	Ap 09	May 09	Jun 09	July 09	Oc 09	Nov 09	Dec 09
ACTION	Preparation						Sampling			Analysis			Evaluation		

III.1. PREPARATION

1. Necessary permission was obtained for sampling.
2. Batteries were checked and replaced as necessary.
3. The calibration of flowmeters on sampling pumps were done.

The calibration was done using a burette, an erlenmeyer, a silicon hose, a stopper, copper piping, and a soap solution. Top of the Erlenmeyer was plugged with the stopper and the copper pipe was placed into the stopper through a bored hole. Burette is connected to the copper pipe by the hose and the entrance of the erlenmeyer was connected to the pump. Flowmeter was calibrated for 2, 3, 4, and 5 lt/min flowrates of the pump by calculating a volume passed by bubble per unit time.



Figure III.1 The Calibration of Air Sampler Flowmeter

4. Leak tests were done for pumps.

5. Clean room cleaning was done with necessary precautions.

6. Cleaning of petri dishes for storing sampling filters was done. In the first step, petri dishes were washed with tap water. Later they were put into the mixture of 20 % nitric acid and 80 % DI water (18 MΩ/cm) for 24 hours. After that they were rinsed with DI water. Petri dishes were put under a laminar flow bench for drying and then they were labeled as necessary.

7. A cage which air samplers placed into during sampling was constructed. The height of the cage was adjusted so that the height of the impactor reached to 90 cm (sitting person's mouth level).

8. The cleaning of impactors was done in an ultrasonic bath. Bath was filled with water into 2/3 level and the water temperature was set to 30 °C. Before being placed into the bath, impactors were washed with hexane. Then they were put into the ultrasonic bath with a basket for 5 minutes. After that they were rinsed with DI water and were placed under the laminar flow bench for drying. This cleaning procedure was repeated in every 6 measurements.

9. Impactors were greased by vacuum grease and installed into sampling heads.

10. The clean room was conditioned by an air conditioner, a dehumidifier and a humidifier to the temperature of 20.9±0.1 °C and to the relative humidity of 34.5±1.2%.

11. After the clean room was conditioned, filters were conditioned in the clean room for 24 hours. Then, empty filters were weighed by a microbalance.

III.2. SAMPLING

III.2.1. Sampling Location Selection

In this study, the goal was the measurements of the particulate matter mass and elemental concentration levels in indoor air environments of the Marmara University Hospital. This hospital is near by to the highway connecting the Asian and European sides of Istanbul, the most crowded city in Turkey.



Figure III.2 Marmara University Hospital



Figure III.3 Marmara University Hospital Location

Two sampling areas have been selected: Children's Polyclinic and Stay Patient's Floor for internal medicine. Table III.2 presents the patient statistics for children's polyclinic. The Stay Patient's Floor has 16 room and 32 beds.

Table III.2 Admission statistics of patients in Children's Polyclinic in 2009

	Patient Kid	Kid Endocrine	Kid Surgery	Kid Psychiatry	Kid Pediatry	Infection	Gastroenterology
Feb	820	444	155	397	51	24	1140
Mar	864	494	164	947	143	48	3491
Apr	813	462	290	347	73	24	1155
	Chest diseases	Nephrology	Cardiology	Infection Pathology	Endocrinology	Hemotology	Medical Oncology
Feb	738	1061	930	228	632	719	945
Mar	991	2691	1057	183	1079	1275	1630
Apr	752	2147	1092	201	723	976	2840



Figure III.4 Sampling in the Children's Polyclinic



Figure III.5 Sampling in the Stay Patient's Floor for Internal Medicine

III.2.2. Sampling Device

The Minivol® Portable Air Samplers were used for our sample collection phase, developed jointly by the Airmetrics Company and the USEPA. The Minivol features a seven day programmable timer, a constant flow control system, an elapsed time totalizer and rechargeable battery packs.

The Minivol Portable Air Sampler can be used to collect either $PM_{2.5}$ or PM_{10}. The PM_{10} impactor (silver) was used for PM_{10} sampling and the $PM_{2.5}$ impactor (gold) was used for $PM_{2.5}$ sampling.



Figure III.6 Sampling Device



Figure III.7 Sampling Head



Figure III.8 Impactors and Other Parts of the Sampling Head



1. PM_{10} particulate matter impactor
2. $PM_{2.5}$ particulate matter impactor
3. Filter holder assembly

Figure III.9 Parts of Sampling Head

III.2.3. Sampling Method

The Minivol's pump draws air at 5 liters/minute through a particle size impactor and then through a filter. Samples were collected on 47 mm Teflon filters with 2 μm pore size. Batteries were charged before the 24 hr sampling stage. Sample collections were performed in children's polyclinic and stay patient's floor for internal medicine. In the children's polyclinic, samples were collected from 9:00 a.m. to 5:30 p.m. since patients are admitted within this period. Samples were collected at stay patient's floor for 24 hours since patients spend all their time there.

Table III.3 Sample collection schedule

Sampling stage	I.	II.	III.	IV.
Sampling site	1	1	2	2
Collected Samples	9 pairs inside	4 pairs inside and outside	4 pairs inside and outside	9 pairs inside
Number of filters used	18 filters	8 filters	8 filters	18 filters
Sampling period	3 days	3 days	daily	daily
Sampling hours	9:00 a.m. -5:30 p.m.	9:00 a.m.-5:30 p.m.	9:00 a.m.-8:30 a.m.	9:00 a.m.-8:30 a.m.
Elapsed sampling time	25.5 hours	25.5 hours	23.5 hours	23.5 hours

Site1: Children's Polyclinic
Site2: Stay Patient's Floor

In the first stage, sampling was performed in the children's polyclinic from 10.02.2009 to 18.03.2009. Sampling period was from 9:00 a.m. to 5:30 p.m. on weekdays only and each filter was used to collect PM on three successive days for about 25.5 hours in total. Simultaneous indoor collections of $PM_{2.5}$ and PM_{10} were performed for 9 pairs of samples (Table III.4).

In the second stage, one of the samplers was placed into its outdoor location at the roof of the next building. Simultaneous indoor and outdoor collections of $PM_{2.5}$ were performed for 2 pairs of samples between 19.03.2009 and 26.03.2009.

Similarly, simultaneous indoor and outdoor collections of PM_{10} were performed for 2 pairs of samples between 27.03.2009 and 03.04.2009 (Table III.5).

In the third stage, simultaneous indoor and outdoor sample collections were performed in the stay patient's floor between 06.04.2009 and 09.04.2009. In this stage, sampling period was from 9:00 a.m. to 8:30 a.m. on weekdays for about 23.5 hours due to the fact that patients spend all their time inside the floor during their stay (Table III.7).

In the fourth stage, sampling was performed in the stay patient's floor from 11.04.2009 to 24.04.2009. Sampling period was similar to that of the third stage on weekdays and weekends. Simultaneous indoor collections of $PM_{2.5}$ and PM_{10} were performed for 9 pairs of samples (Table III.6).

Table III.4 Indoor air sample collection details for Site 1

Filter No	Date	PM Size [μm]	Sampling Duration [hr]
S1	10/11/12.02.09	2.5	25.6
S2	10/11/12.02.09	10	25.5
S3	13/16/17.02.09	2.5	25.4
S4	13/16/17.02.09	10	25.5
S5	18/19/20.02.09	2.5	25.6
S6	18/19/20.02.09	10	25.5
S7	23/24/25.02.09	2.5	25.4
S8	23/24/25.02.09	10	25.5
S9	26/27.02-02.03.09	2.5	25.6
S10	26/27.02-02.03.09	10	25.5
S11	03/04/05.03.09	2.5	25.4
S12	03/04/05.03.09	10	17.1
S13	06/09/10.03.09	2.5	25.6
S14	06/09/10.03.09	10	25.5
S15	11/12/13.03.09	2.5	25.4
S16	11/12/13.03.09	10	17
S17	16/17/18.03.09	2.5	25.6
S18	16/17/18.03.09	10	25.5

Table III.5 Simultaneous outdoor and indoor air sample collection details for Site 1

Filter No	Date	PM Size [μm]	Location	Sampling Duration [hr]
S19	19/20/23.03.2009	2.5	outdoor	25.4
S20	19/20/23.03.2009	2.5	indoor	25.5
S21	24/25/26.03.2009	2.5	outdoor	25.6
S22	24/25/26.03.2009	2.5	indoor	25.5
S23	27/30/31.03.2009	10	outdoor	25.4
S24	27/30/31.03.2009	10	indoor	25.5
S25	01/02/03.04.2009	10	outdoor	25.6
S26	01/02/03.04.2009	10	indoor	25.5

Table III.6 Indoor air sample collection details for Site 2

Filter No	Date	PM Size [μm]	Sampling Day	Sampling Duration [hr]
S35	11.04.09	2.5	Weekend	23.4
S36	11.04.09	10	Weekend	23.5
S37	12.04.09	2.5	Weekend	15.9
S38	12.04.09	10	Weekend	23.5
S39	14.04.09	2.5	Weekday	23.5
S40	14.04.09	10	Weekday	23.5
S42	15.04.09	10	Weekday	23.5
S43	16.04.09	2.5	Weekday	23.5
S44	16.04.09	10	Weekday	23.5
S45	18.04.09	2.5	Weekend	23.5
S46	18.04.09	10	Weekend	23.5
S47	19.04.09	2.5	Weekend	23.5
S48	19.04.09	10	Weekend	23.5
S49	20.04.09	2.5	Weekday	23.5
S50	20.04.09	10	Weekday	23.5
S51	21.04.09	2.5	Weekday	19.8
S52	21.04.09	10	Weekday	23.5
S53	22.04.09	2.5	Weekday	23.5
S54	22.04.09	10	Weekday	23.5
S55	24.04.09	2.5	Weekday	23.5
S56	24.04.09	10	Weekday	23.5

Table III.7 Simultaneous outdoor and indoor air sample collection details for Site 2

Filter No	Date	PM Size [μm]	Location	Sampling Day	Sampling Duration [hr]
S27	06.04.09	10	outdoor	weekday	23.4
S28	06.04.09	10	indoor	weekday	23.5
S29	07.04.09	10	outdoor	weekday	23.6
S30	07.04.09	10	indoor	weekday	23.5
S31	08.04.09	2.5	outdoor	weekday	23.4
S32	08.04.09	2.5	indoor	weekday	23.5
S33	09.04.09	2.5	outdoor	weekday	23.6
S34	09.04.09	2.5	indoor	weekday	23.5

CHAPTER IV

RESULTS and DISCUSSION

IV.1. MASS CONCENTRATIONS

Mass concentrations for $PM_{2.5}$ and PM_{10} samples were determined by gravimetric approach. The net weights of the PM material collected on Teflon filters were obtained by subtracting the empty filter weight from the full filter weight. The clean room used for sample preparations was conditioned to a temperature of 21.7±0.1 °C and a relative humidity of 30.2±1.2 % during the filter weighing operations. After the clean room was conditioned, filters were placed on a laminar flow bench located in the clean room area for 24 hours to equalize their moisture levels to that of the clean room air. After this stage, the filters were weighted on a microbalance.

IV.1.1. Children's Polyclinic (Site 1)

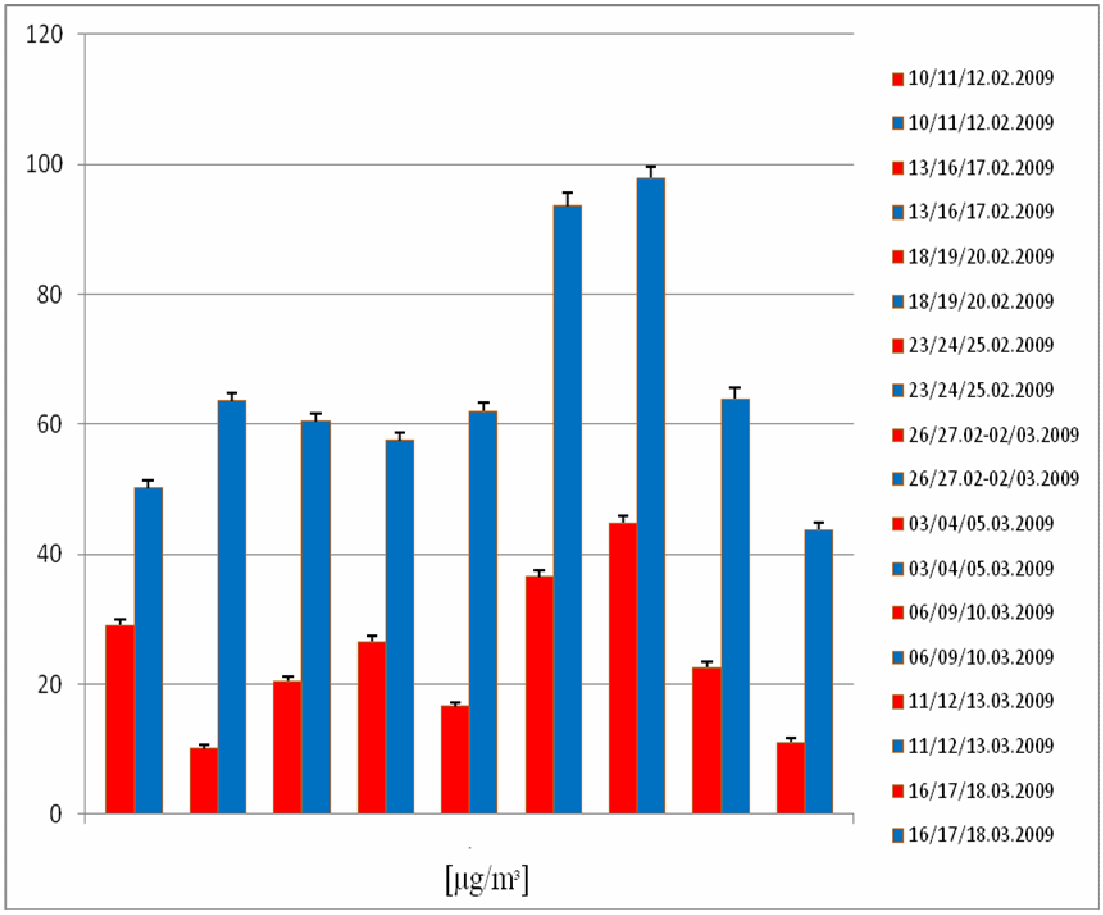
The gravimetrically obtained PM mass concentrations for this site are presented in Table IV.1 and Figure IV.1.

Table IV.1 PM mass concentrations in Site 1

Filter No	Mass of PM [µg]	Air Volume [m³]	Mass Concentration [µg/m³]
S1	223	7.68	29.04±0.87
S2	384	7.65	50.20±1.12
S3	77	7.62	10.10±0.65
S4	486	7.65	63.53±1.28
S5	157	7.68	20.44±0.77
S6	462	7.65	60.39±1.25

Table IV.1 Continued

Filter No	Mass of PM [µg]	Air Volume [m³]	Mass Concentration [µg/m³]
S7	202	7.62	26.51±0.84
S8	440	7.65	57.52±1.21
S9	127	7.68	16.54±0.72
S10	474	7.65	61.96±1.26
S11	278	7.62	36.48±0.96
S12	480	5.13	93.57±1.99
S13	344	7.68	44.79±1.06
S14	749	7.65	97.91±1.69
S15	172	7.62	22.57±0.80
S16	326	5.1	63.92±1.61
S17	85	7.68	11.07±0.65
S18	335	7.65	43.79±1.05



Red: $PM_{2.5}$ Blue: PM_{10}

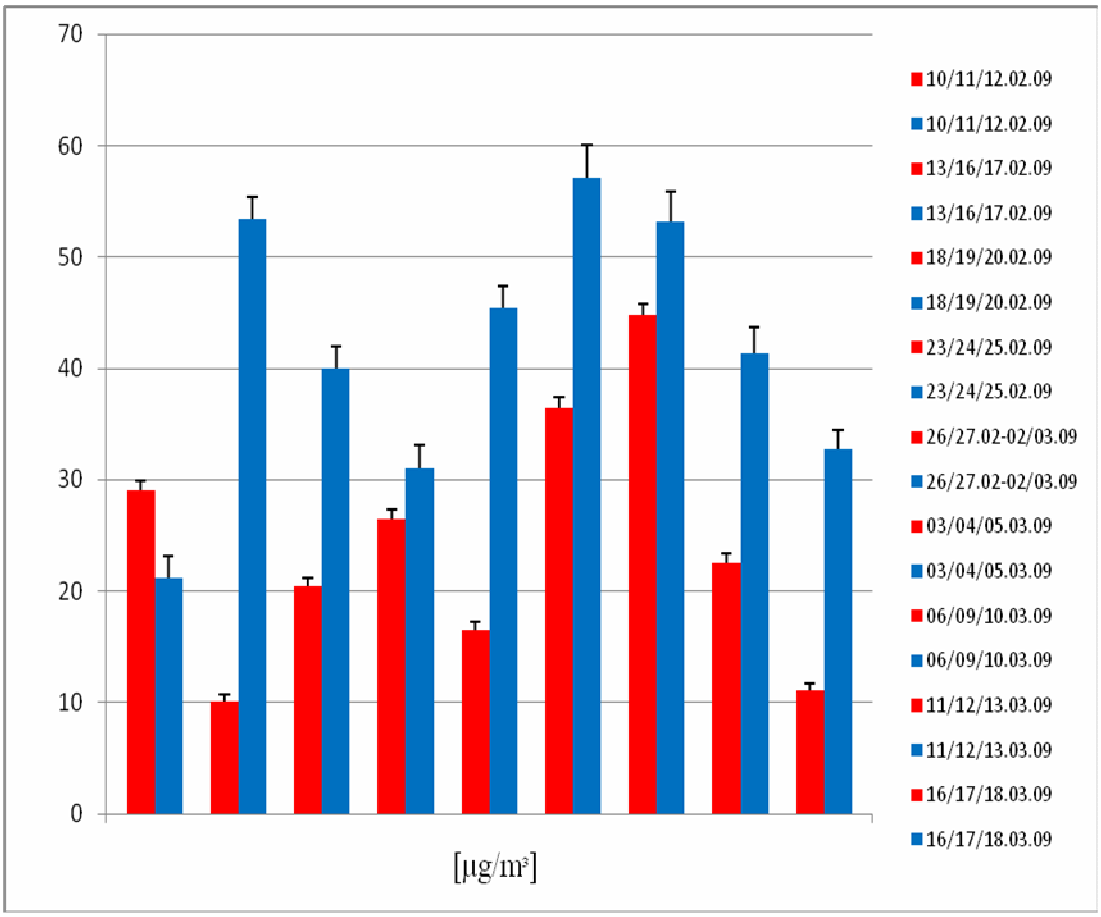
Figure IV.1 PM_{10} and $PM_{2.5}$ mass concentrations in Site 1

The obtained PM mass concentration values were compared to the standards of WHO, EPA, and Turkish Environmental Law and results are presented in Table IV.2. As it can be seen from the table, the measured PM_{10} mass concentrations are under the limit of Turkish standards while they are above the limit of WHO. For $PM_{2.5}$, the values are above the limits of both WHO and EPA. Currently, Turkish Environmental Law has no standard for $PM_{2.5}$.

Table IV.2 Comparison of mass concentrations in Site 1

Filter No	**Type**	**Mass Concentration [µg/m³]**	**WHO ($PM_{2.5}$:10 µg/m³) (PM_{10}:25 µg/m³)**	**EPA ($PM_{2.5}$:15 µg/ m³)**	**Turkish Standard (PM_{10}:150 µg/m³)**
S1	$PM_{2.5}$	29.04	AL	AL	NA
S2	PM_{10}	50.20	AL	NA	BL
S3	$PM_{2.5}$	10.11	AL	BL	NA
S4	PM_{10}	63.53	AL	NA	BL
S5	$PM_{2.5}$	20.44	AL	AL	NA
S6	PM_{10}	60.39	AL	NA	BL
S7	$PM_{2.5}$	26.51	AL	AL	NA
S8	PM_{10}	57.52	AL	NA	BL
S9	$PM_{2.5}$	16.54	AL	AL	NA
S10	PM_{10}	61.96	AL	NA	BL
S11	$PM_{2.5}$	36.48	AL	AL	NA
S12	PM_{10}	93.57	AL	NA	BL
S13	$PM_{2.5}$	44.79	AL	AL	NA
S14	PM_{10}	97.91	AL	NA	BL
S15	$PM_{2.5}$	22.57	AL	AL	NA
S16	PM_{10}	63.92	AL	NA	BL
S17	$PM_{2.5}$	11.07	AL	BL	NA
S18	PM_{10}	43.79	AL	NA	BL

AL: Above Limit, BL: Below Limit, NA: Not Applicable



Red:Fine Particles Blue: Coarse Particles

Figure IV.2 Coarse and Fine fraction mass concentrations in Site 1

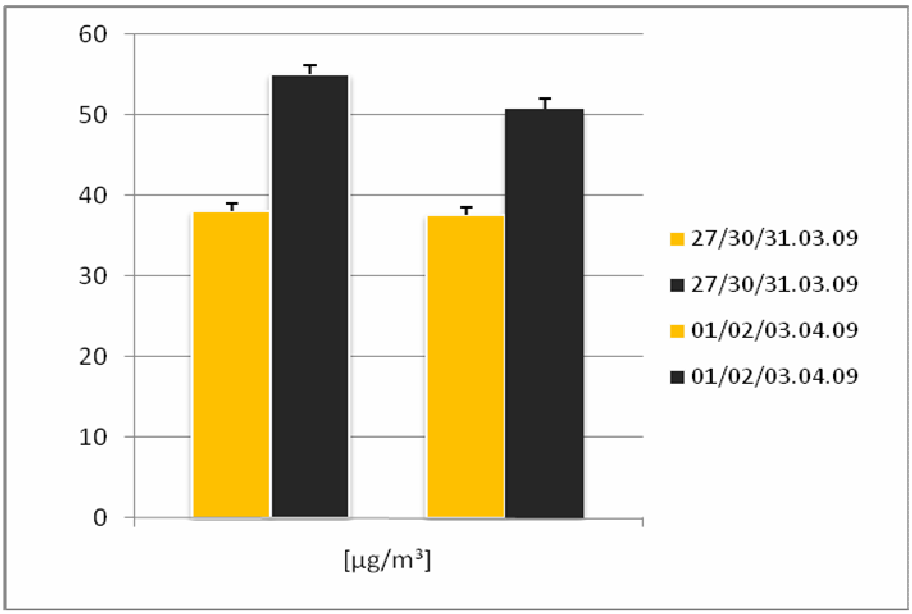
Another measure used in PM classification is the fine ($PM_{2.5}$) and coarse (PM_{10}-$PM_{2.5}$) fraction of samples. The Figure IV.2 presents this measure for the Children's Polyclinic. Mass concentration results for simultaneous outdoor and indoor PM measurements for the Children's Polyclinic are presented in Table IV.3. As it can be seen from Table IV.4, the measured PM_{10} mass concentrations are under the limit of Turkish standards while they are above the limit of WHO. The limited number of measurements shows that indoor PM_{10} concentrations are higher compared to the outdoor concentrations (Figure IV.3). The most likely reason for this result is the people's activities inside this site and the resulting re-suspension of the floor dust into the indoor air environment. Both above and below the limit values of WHO and EPA were observed for $PM_{2.5}$ concentrations in this site. As opposed to the PM_{10} concentrations, outdoor $PM_{2.5}$ concentrations are higher than the indoor concentrations (Figure IV.4). It is likely that the main source of $PM_{2.5}$ in this site is the outdoor to indoor transport of air.

Table IV.3 Simultaneous outdoor and indoor PM mass concentrations in Site 1

Filter No	Place	Mass of PM [µg]	Air Volume [m^3]	Mass Concentration [$\mu g/m^3$]
S19	outdoor	45	7.62	5.91±0.60
S20	indoor	25	7.65	3.27±0.56
S21	outdoor	201	7.68	26.17±0.83
S22	indoor	123	7.65	16.08±0.72
S23	outdoor	290	7.62	38.06±0.98
S24	indoor	421	7.65	55.03±1.18
S25	outdoor	289	7.68	37.63±0.97
S26	indoor	389	7.65	50.85±1.13

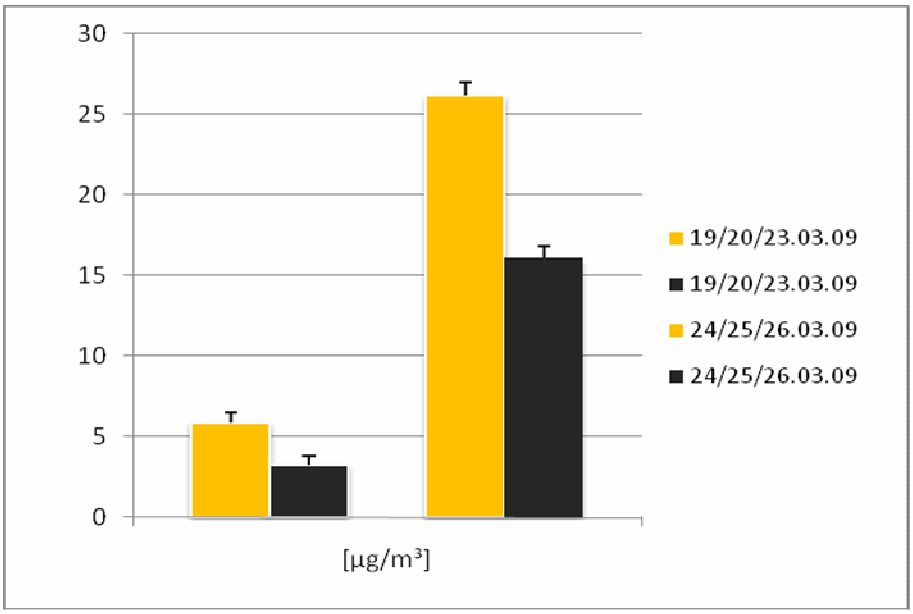
Table IV.4 Comparison of outdoor and indoor PM mass concentrations in Site 1

Filter No	Type	Place	Mass Concentration [$\mu g/m^3$]	WHO ($PM_{2.5}$:10$\mu g/m^3$) (PM_{10}:25$\mu g/m^3$)	EPA ($PM_{2.5}$:15$\mu g/m^3$)	Turkish Standard (PM_{10}:150$\mu g/m^3$)
S19	$PM_{2.5}$	outdoor	5.91	BL	BL	NA
S20	$PM_{2.5}$	indoor	3.27	BL	BL	NA
S21	$PM_{2.5}$	outdoor	26.17	AL	AL	NA
S22	$PM_{2.5}$	indoor	16.08	AL	AL	NA
S23	PM_{10}	outdoor	38.06	AL	NA	BL
S24	PM_{10}	indoor	55.03	AL	NA	BL
S25	PM_{10}	outdoor	37.63	AL	NA	BL
S26	PM_{10}	indoor	50.85	AL	NA	BL



Yellow:Outdoor Particles Black: Indoor Particles

Figure IV.3 Simultaneous indoor and outdoor PM_{10} mass concentrations in Site 1



Yellow:Outdoor Particles Black: Indoor Particles

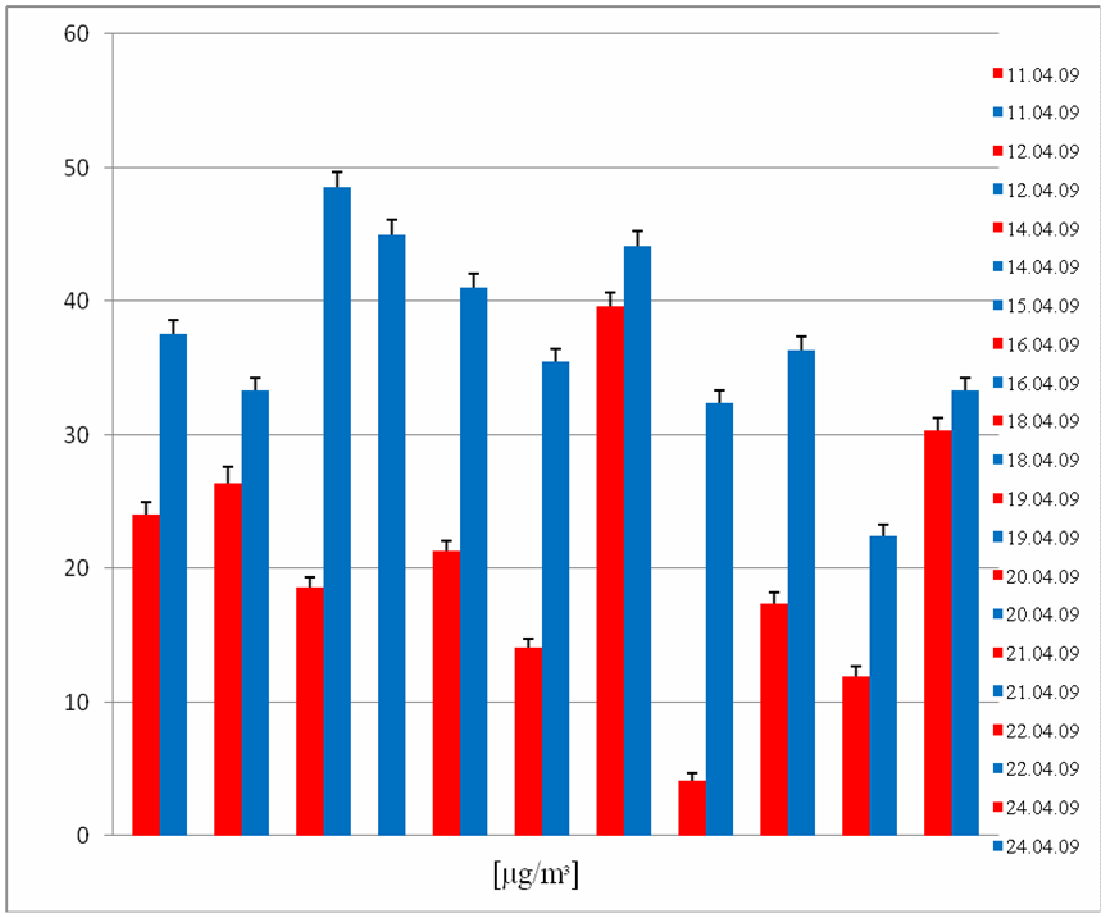
Figure IV.4 Simultaneous indoor and outdoor $PM_{2.5}$ mass concentrations in Site 1

IV.1.2. Stay Patient's Floor (Site 2)

The gravimetrically obtained PM mass concentrations for this site are presented in Table IV.5 and Figure IV.5.

Table IV.5 PM mass concentrations in Site 2

Filter No	Time	Mass of PM [µg]	Air Volume [m^3]	Mass Concentration [$\mu g/m^3$]
S35	Weekend	169	7.02	24.07±0.86
S36	Weekend	265	7.05	37.59±1.02
S37	Weekend	126	4.77	26.42±1.19
S38	Weekend	235	7.05	33.33±0.97
S39	Weekday	131	7.05	18.58±0.79
S40	Weekday	342	7.05	48.51±1.16
S42	Weekday	317	7.05	44.96±1.11
S43	Weekday	150	7.05	21.28±0.83
S44	Weekday	289	7.05	40.99±1.07
S45	Weekend	99	7.05	14.04±0.74
S46	Weekend	250	7.05	35.46±1.00
S47	Weekend	279	7.05	39.57±1.05
S48	Weekend	311	7.05	44.11±1.10
S49	Weekday	29	7.05	4.11±0.62
S50	Weekday	228	7.05	32.34±0.96
S51	Weekday	103	5.94	17.34±0.89
S52	Weekday	256	7.05	36.31±1.01
S53	Weekday	84	7.05	11.91±0.71
S54	Weekday	158	7.05	22.41±0.84
S55	Weekday	214	7.05	30.35±0.94
S56	Weekday	235	7.05	33.33±0.97



Red: $PM_{2.5}$ Blue: PM_{10}

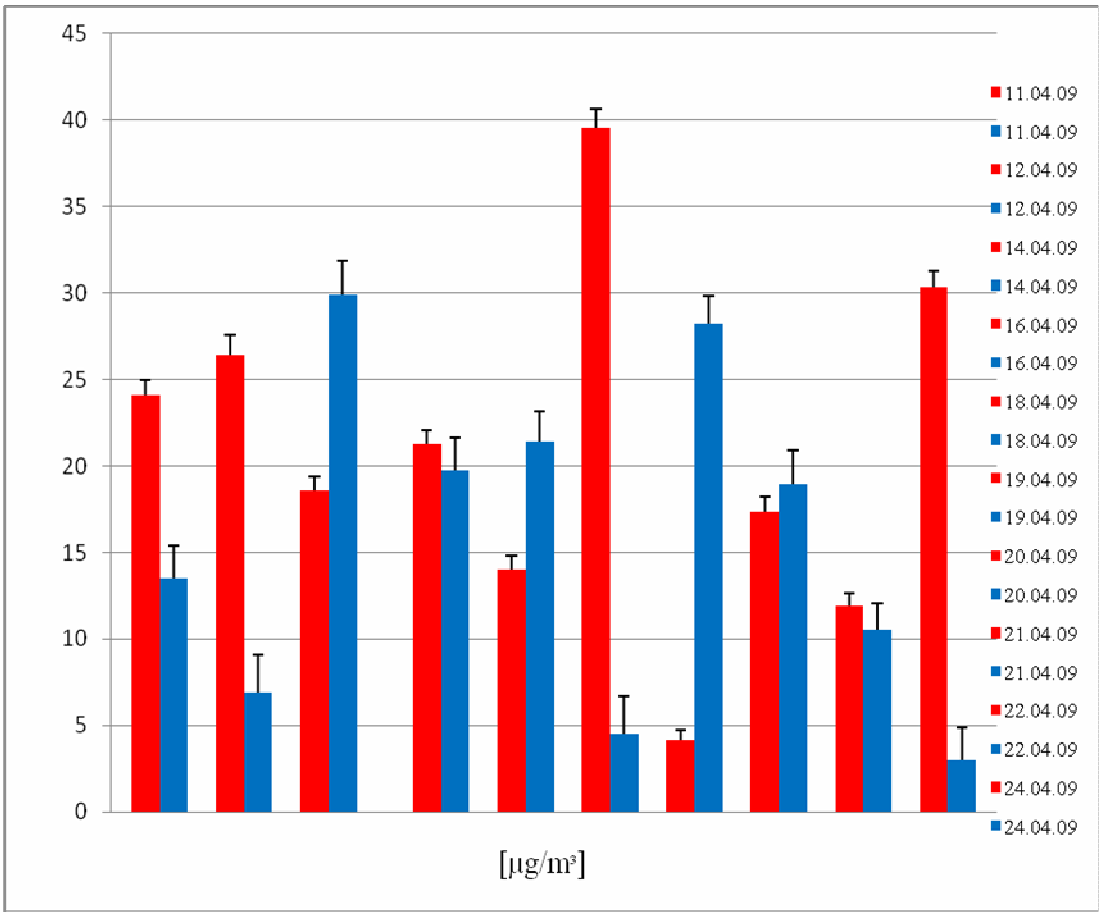
Figure IV.5 PM_{10} and $PM_{2.5}$ mass concentrations in Site 2

The Figure IV.6 presents the coarse and fine fraction mass concentrations for the stay patient's floor. The obtained PM mass concentration values were compared to the standards of WHO, EPA, and Turkish Environmental Law and results are presented in Table IV.6. As it can be seen from the table, the measured PM_{10} mass concentrations are under the limit of Turkish standards while they are above the limit of WHO. For $PM_{2.5}$, the values are above the limits of both WHO and EPA. Currently, Turkish Environmental Law has no standard for $PM_{2.5}$.

Table IV.6 Comparison of mass concentrations in Site 2

Filter No	Type	Mass Concentration [µg/m³]	WHO ($PM_{2.5}$:10µg/m³) (PM_{10}:25µg/m³)	EPA ($PM_{2.5}$:15µg/m³)	Turkish Standard (PM_{10}:150µg/m³)
S35	$PM_{2.5}$	24.07	AL	AL	NA
S36	PM_{10}	37.59	AL	NA	BL
S37	$PM_{2.5}$	26.42	AL	AL	NA
S38	PM_{10}	33.33	AL	NA	BL
S39	$PM_{2.5}$	18.58	AL	AL	NA
S40	PM_{10}	48.51	AL	NA	BL
S42	PM_{10}	44.96	AL	NA	BL
S43	$PM_{2.5}$	21.28	AL	AL	NA
S44	PM_{10}	40.99	AL	NA	BL
S45	$PM_{2.5}$	14.04	AL	BL	NA
S46	PM_{10}	35.46	AL	NA	BL
S47	$PM_{2.5}$	39.57	AL	AL	NA
S48	PM_{10}	44.11	AL	NA	BL
S49	$PM_{2.5}$	4.11	BL	BL	NA
S50	PM_{10}	32.34	AL	NA	BL
S51	$PM_{2.5}$	17.34	AL	AL	NA
S52	PM_{10}	36.31	AL	NA	BL
S53	$PM_{2.5}$	11.91	AL	BL	NA
S54	PM_{10}	22.41	BL	NA	BL
S55	$PM_{2.5}$	30.35	AL	AL	NA
S56	PM_{10}	33.33	AL	NA	BL

AL: Above Limit, BL: Below Limit, NA: Not Applicable



Red:Fine Particles Blue: Coarse Particles

Figure IV.6 Coarse and Fine fraction mass concentrations in Site 2

Mass concentration results for simultaneous outdoor and indoor PM measurements for the Children's Polyclinic are presented in Table IV.7. As it can be seen from Table IV.8, the measured PM_{10} mass concentrations are under the limit of Turkish standards while they are above the limit of WHO. The limited number of measurements shows that outdoor and indoor PM_{10} concentrations are close to each other (Figure IV.7). Considering that there are much fewer people in Stay Patient's Floor compared to the Children's Polyclinic, it is understandable that the floor dust re-suspension would contribute less to this site. In this site, $PM_{2.5}$ concentrations were also above the limits of WHO and EPA. Outdoor $PM_{2.5}$ concentrations were higher than the indoor concentrations (Figure IV.8). It is likely that the main source of $PM_{2.5}$ in this site is the outdoor to indoor transport of air.

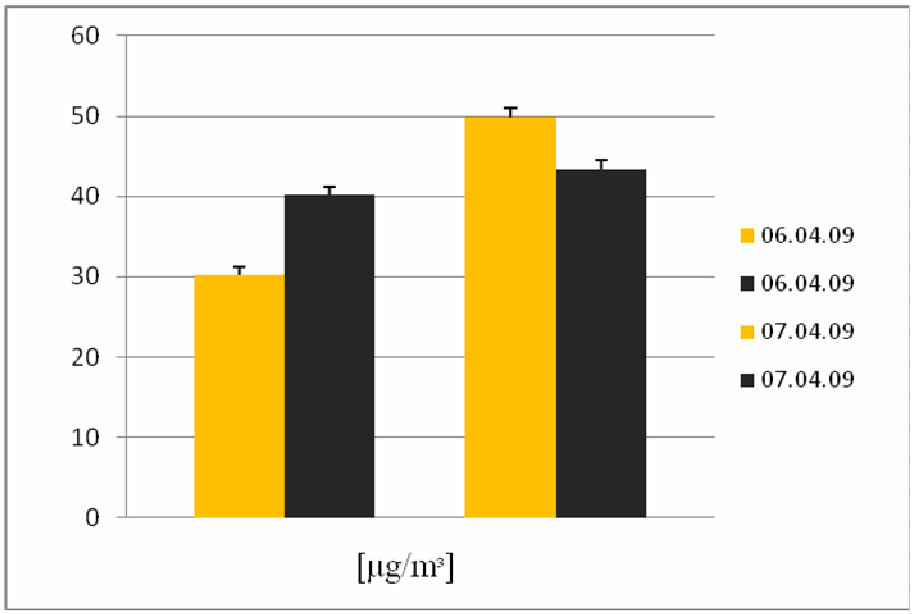
Table IV.7 Simultaneous outdoor and indoor PM mass concentrations in Site 2

Filter No	Place	Mass of PM [µg]	Air Volume [m^3]	Mass Concentration [$\mu g/m^3$]
S27	outdoor	212	7.02	30.20±0.94
S28	indoor	283	7.05	40.14±1.05
S29	outdoor	353	7.08	49.86±1.17
S30	indoor	306	7.05	43.40±1.09
S31	outdoor	465	7.02	66.24±1.37
S32	indoor	139	7.05	19.72±0.81
S33	outdoor	203	7.08	28.67±0.91
S34	indoor	103	7.05	14.61±0.75

Table IV.8 Comparison of outdoor and indoor PM mass concentrations in Site 2

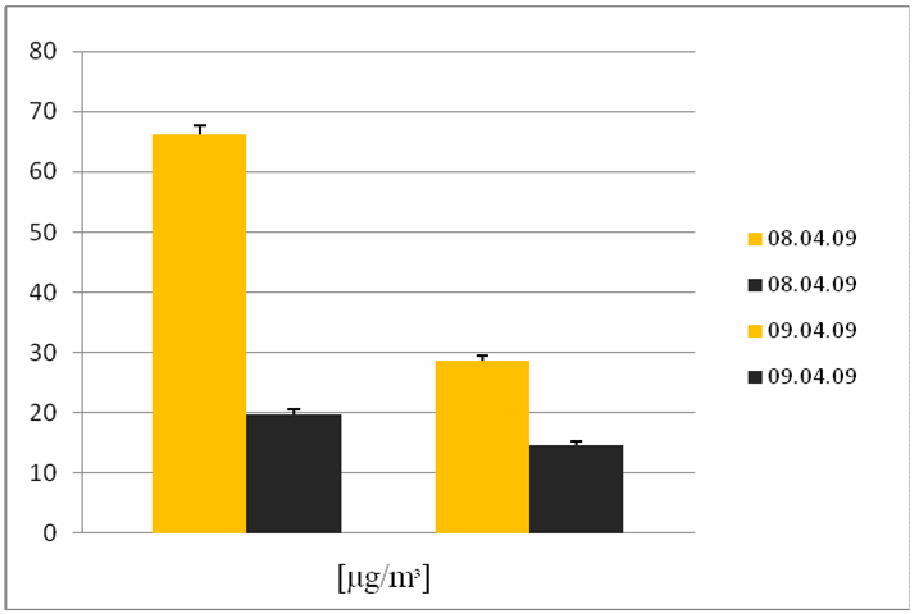
Filter No	Type	Place	Mass Concentration [$\mu g/m^3$]	WHO ($PM_{2.5}$:10$\mu g/m^3$) (PM_{10}:25$\mu g/m^3$)	EPA ($PM_{2.5}$:15$\mu g/m^3$)	Turkish Standard (PM_{10}:150$\mu g/m^3$)
S27	PM_{10}	outdoor	30.20	AL	NA	BL
S28	PM_{10}	indoor	40.14	AL	NA	BL
S29	PM_{10}	outdoor	49.86	AL	NA	BL
S30	PM_{10}	indoor	43.40	AL	NA	BL
S31	$PM_{2.5}$	outdoor	66.24	AL	AL	NA
S32	$PM_{2.5}$	indoor	19.72	AL	AL	NA
S33	$PM_{2.5}$	outdoor	28.67	AL	AL	NA
S34	$PM_{2.5}$	indoor	14.61	AL	BL	NA

AL: Above Limit, BL: Below Limit, NA: Not Applicable



Yellow:Outdoor Particles Black: Indoor Particles

Figure IV.7 Simultaneous indoor and outdoor PM_{10} mass concentrations in Site 2



Yellow:Outdoor Particles Black: Indoor Particles

Figure IV.8 Simultaneous indoor and outdoor $PM_{2.5}$ mass concentrations in Site 2

IV.2. ELEMENTAL CONCENTRATIONS

Elemental analyses of PM samples were performed by Inductively Coupled Plasma–Mass Spectrometry (ICP-MS) technique. Before the analyses, sample preparation bottles and microwave digestion pressure tubes were acid washed. For this purpose, they were soaked in 20 % nitric acid and 80 % de-ionized (DI) water (18 MΩ/cm) mixture for 24 hours. All the Teflon® filters were separated from their rings by a lance and placed into microwave digestion pressure tubes. Following this,

3 ml of 65 % nitric acid and 1 ml of 30 % hydrochloric acid (both Merck Suprapur® grade) were added into each pressure tube. For the microwave digestion process, pressure tubes were heated up to 180 °C within the first 5 minutes and kept at this temperature for another 25 minutes. After the cooling down period, tubes were opened and 21 ml of DI water added into each tube. These sample solutions were transferred into pre-cleaned bottles and then filtered through filters (0,20 μm pore size Sartorius Minisart® SRP 25) into other pre-cleaned sample bottles in 25 ml volumes using 10 ml sterile syringes. Prepared samples were analyzed by ICP-MS measurements using multi-element standard reference solutions (Merck) and concentrations of elements Na, Mg, Al, K, Ca, Mn, Fe, Co, Cu, Zn, Se, Mo, Cd, Sb, Ba, and Pb were obtained. Some statistics for these elements are given in Table IV.9 and Table IV.10 for Site 1 and Site 2, respectively. Elemental concentration results in μg/m³ are given for all samples in Appendix A. Among these trace elements, Cd, Pb, and Mn have annual average limit values set by WHO as 0.005 μg/m³, 0.5 μg/m³, and 0.15 μg/m³, respectively. As it can be seen from the results given in Table IV.9 and Table IV.10, measured concentrations for these elements are well below these limits, for both sites.

Table IV.9 Some statistics for elemental concentrations in Site 1

Element	Average Conc.[μg/m³]	Std.Dev. [μg/m³]	Range [μg/m³]	Element	Average Conc.[μg/m³]	Std.Dev. [μg/m³]	Range [μg/m³]
Na($PM_{2.5}$)	0.20	0.09	0.1-0.37	**Cu($PM_{2.5}$)**	0.008	0.002	0.006-0.012
Na(PM_{10})	0.62	0.22	0.42-1.02	**Cu(PM_{10})**	0.02	0.01	0.01-0.03
Mg($PM_{2.5}$)	0.09	0.09	0.04-0.35	**Zn($PM_{2.5}$)**	0.124	0.11	0.027-0.38
Mg(PM_{10})	0.35	0.24	0.2-0.98	**Zn(PM_{10})**	0.166	0.16	0.043-0.52
Al($PM_{2.5}$)	0.19	0.24	0.07-0.86	**Se($PM_{2.5}$)**	0.00088	0.00026	0.00046-0.00126
Al(PM_{10})	0.62	0.50	0.34-1.95	**Se(PM_{10})**	0.00111	0.00158	0.00019-0.0053
K($PM_{2.5}$)	0.24	0.05	0.18-0.34	**Mo($PM_{2.5}$)**	0.00065	0.00044	0.00016-0.0017
K(PM_{10})	0.49	0.14	0.39-0.84	**Mo(PM_{10})**	0.00129	0.00095	0.0006-0.0037
Ca($PM_{2.5}$)	1.08	0.54	0.55-2.17	**Cd($PM_{2.5}$)**	0.00048	0.00031	0.00016-0.0012
Ca(PM_{10})	3.94	1.59	2.35-6.9	**Cd(PM_{10})**	0.000445	0.00013	0.00027-0.00069
Mn($PM_{2.5}$)	0.0062	0.0028	0.0036-0.012	**Sb($PM_{2.5}$)**	0.0011	0.0003	0.0007-0.002
Mn(PM_{10})	0.0163	0.0072	0.006-0.0317	**Sb(PM_{10})**	0.0021	0.0007	0.0015-0.0037

Table IV.9 Continued

Fe($PM_{2.5}$)	0.20	0.16	0.12-0.64	**Ba($PM_{2.5}$)**	0.0047	0.0019	0.0028-0.0089
Fe(PM_{10})	0.73	0.36	0.46-1.63	**Ba(PM_{10})**	0.016	0.003	0.012-0.021
Co($PM_{2.5}$)	0.00032	0.00022	0.00002-0.00069	**Pb($PM_{2.5}$)**	0.0145	0.0074	0.0067-0.031
Co(PM_{10})	0.00046	0.0002	0.00028-0.00089	**Pb(PM_{10})**	0.0167	0.0069	0.0083-0.0296

Table IV.10 Some statistics for elemental concentrations in Site 2

Element	**Average Conc.[µg/m³]**	**Std.Dev. [µg/m³]**	**Range [µg/m³]**	**Element**	**Average Conc.[µg/m³]**	**Std.Dev. [µg/m³]**	**Range [µg/m³]**
Na($PM_{2.5}$)	1.25	0.51	0.37-1.9	**Cu($PM_{2.5}$)**	0.013	0.02	0.004-0.068
Na(PM_{10})	2.06	0.84	0.71-3.21	**Cu(PM_{10})**	0.016	0.0067	0.0065-0.028
Mg($PM_{2.5}$)	0.07	0.05	0.03-0.18	**Zn($PM_{2.5}$)**	0.150	0.156	0.0028-0.48
Mg(PM_{10})	0.23	0.10	0.13-0.49	**Zn(PM_{10})**	0.243	0.279	0.025-0.85
Al($PM_{2.5}$)	0.09	0.11	0.03-0.38	**Se($PM_{2.5}$)**	0.0005	0.00029	0.00005-0.00106
Al(PM_{10})	0.26	0.10	0.15-0.51	**Se(PM_{10})**	0.0005	0.00036	0.0002-0.0014
K($PM_{2.5}$)	0.21	0.04	0.16-0.27	**Mo($PM_{2.5}$)**	0.00051	0.00075	0.00015-0.0026
K(PM_{10})	0.36	0.05	0.3-0.42	**Mo(PM_{10})**	0.00092	0.00093	0.00021-0.0034
Ca($PM_{2.5}$)	0.52	0.27	0.13-1.11	**Cd($PM_{2.5}$)**	0.0004	0.00049	0.00005-0.0016
Ca(PM_{10})	1.47	0.56	0.47-2.64	**Cd(PM_{10})**	0.00071	0.00087	0.000064-0.003
Mn($PM_{2.5}$)	0.0045	0.0024	0.0017-0.0092	**Sb($PM_{2.5}$)**	0.00142	0.00053	0.00094-0.0026
Mn(PM_{10})	0.0097	0.0046	0.0048-0.019	**Sb(PM_{10})**	0.0023	0.0007	0.0015-0.0039
Fe($PM_{2.5}$)	0.230	0.193	0.046-0.72	**Ba($PM_{2.5}$)**	0.0037	0.0017	0.0012-0.006
Fe(PM_{10})	0.492	0.142	0.36-0.76	**Ba(PM_{10})**	0.0096	0.0034	0.0046-0.02
Co($PM_{2.5}$)	0.00013	0.00008	0.00005-0.00025	**Pb($PM_{2.5}$)**	0.0119	0.0082	0.0038-0.025
Co(PM_{10})	0.00055	0.00081	0.00001-0.0027	**Pb(PM_{10})**	0.0146	0.0104	0.0048-0.033

IV.3. ENRICHMENT FACTORS

The enrichment factor (EF) concept is used to understand the possible contribution from soil dust and marine salt to the observed elemental concentrations in the samples. For this purpose, since they do not have any other significant sources except very specific cases, Al and Na are generally used as reference elements for soil dust and marine contributions, respectively. The value of EF with respect to Al shows if soil dust can be a major source of an element in a sample or not. Similarly, the value of EF with respect to Na shows if marine salt can be a major source of an element in a sample or not. The EF concept is formulated as

$$EF=(X/Al)_{PM} / (X/Al)_{crust}$$

$$EF=(X/Na)_{PM} / (X/Na)_{marine}$$

and generally accepted that, elements with EF values above 5 are enriched with respect to soil dust or marine salt and they are thought to have some other sources such as anthropogenic activities. All EF results for Coarse (PM_{10}-$PM_{2.5}$) and fine ($PM_{2.5}$) fractions with respect to Al and Na are given in Appendix B. Some statistics for EF's in Site 1 are given in Table IV.11 and Table IV.12 with respect to Al and Na, respectively. Similar results for Site 2 are given in Table IV.13 and Table IV.14 with respect to Al and Na, respectively.

The calculated EF values with respect to Al and Na for both sites show that Fe and Mn are mainly originate from soil dust in both fine ($PM_{2.5}$) and coarse (PM_{10}-$PM_{2.5}$) fractions. Mg seems to originate from both soil dust and sea salt aerosols. Na, K, and Co are generally enriched in fine mode but not enriched in coarse mode. This means that while they mainly originate from soil dust in coarse mode, they have other sources in fine mode. It is highly likely that Na in fine mode originate from sea salt spray from nearby Marmara Sea. It is known that K might originate mainly from wood burning activities while Co is more likely to originate from coal combustion, traffic emissions, and waste incineration processes in fine mode. Trace elements Cu, Zn, Se, Mo, Cd, Sb, and Pb are highly enriched with respect to Al and Na. Therefore, they should have strong emission sources other than soil dust and sea salt. It is known from the scientific literature that these elements are mainly related to traffic emissions and fuel combustion processes. Considering that the sampling location is nearby to crowded streets, traffic seems to be the major contributor to the observed concentrations.

Coarse to fine EF ratios for all measured elements given in Appendix C show that Na, K, Mn, Co, Cu, Zn, Se, Mo, Cd, Sb, and Pb have ratios below 1 in general and they are enriched more in fine mode. Considering their major sources, this is an expected result. Similar analysis shows that Mg, Fe, and Ba are more enriched in the coarse mode. Some statistics are presented in Table IV.15, Table IV.16, Table IV.17 and Table IV.18 for coarse to fine EF ratios in Site 1 and Site 2, respectively.

Table IV.11 Some statistics for EF with respect to Al in Site 1

Element	AverageEF	Std.Dev.	Range	Element	AverageEF	Std.Dev.	Range
Na(Fine)	6.0	3.7	1.3-13.8	**Zn(Fine)**	1048	910	340-2908
Na(Coarse)	3.8	1.7	2-7.6	**Zn(Coarse)**	374	470	71-1385
Mg(Fine)	2.0	0.5	1.4-3.1	**Se(Fine)**	13119	5496	1304-20081
Mg(Coarse)	2.1	0.2	1.9-2.6	**Se(Coarse)**	8563	13087	91-23635
K(Fine)	8.2	2.8	1.6-12.1	**Mo(Fine)**	330	294	42-1009
K(Coarse)	2.3	0.3	1.8-2.6	**Mo(Coarse)**	181	175	58-527
Ca(Fine)	18.9	13.9	3.6-48.5	**Cd(Fine)**	1819	1293	110-4366
Ca(Coarse)	13.6	5.8	6.3-27.4	**Cd(Coarse)**	116	139	4-405
Mn (Fine)	4.2	1.7	1.2-6.9	**Sb(Fine)**	4271	1698	422-6071
Mn(Coarse)	2.1	0.8	0.2-2.7	**Sb(Coarse)**	1021	565	254-1969
Fe(Fine)	2.0	0.5	1.1-2.6	**Ba(Fine)**	8.4	6.2	1.5-23.2
Fe(Coarse)	1.9	0.3	1.3-2.2	**Ba(Coarse)**	5.5	1.6	2.5-7.8
Co(Fine)	9.2	7.5	0.7-20.6	**Pb(Fine)**	887	553	74-2018
Co(Coarse)	2.1	0.9	0.7-3.6	**Pb(Coarse)**	87	41	16-144
Cu(Fine)	116.6	52.3	12.8-194				
Cu(Coarse)	57.3	22.0	20.5-86.6				

Table IV.12 Some statistics for EF with respect to Na in Site 1

Element	Average EF	Std. Dev.	Range
Mg (Fine)	3.3	2.1	1.7-8.2
Mg (Coarse)	4.9	1.6	2.4-7.8
K (Fine)	37.6	12.8	16.8-56.9
K (Coarse)	17.3	5.8	7.1-25.6

Table IV.13 Some statistics for EF with respect to Al in Site 2

Element	AverageEF	Std.Dev.	Range	Element	AverageEF	Std.Dev.	Range
Na(Fine)	85.4	58.2	14-157	**Zn(Fine)**	3521	3672	67-10737
Na(Coarse)	18.8	11.8	4.7-40.7	**Zn(Coarse)**	898	1047	261-2455
Mg(Fine)	4.6	3.6	1.7-11.9	**Se(Fine)**	15161	13385	2454-48024
Mg(Coarse)	3.5	2.2	2.1-8.7	**Se(Coarse)**	6212	6659	1776-13869
K(Fine)	15.2	6.9	2.5-29.1	**Mo(Fine)**	516	793	28-2748
K(Coarse)	3.7	1.1	2.3-5.6	**Mo(Coarse)**	137	100	12-340
Ca(Fine)	20.2	16.5	2.7-54.3	**Cd(Fine)**	3771	6147	156-20100
Ca(Coarse)	11.9	8.8	3.3-33.6	**Cd(Coarse)**	1247	2996	26-8657
Mn (Fine)	6.0	2.5	1.7-11.2	**Sb(Fine)**	9748	3561	2801-15519
Mn(Coarse)	2.7	1.1	1.3-5.1	**Sb(Coarse)**	2446	791	931-3460
Fe(Fine)	5.3	4.4	1.4-16.7	**Ba(Fine)**	11.6	4.7	2.9-17.7
Fe(Coarse)	2.9	0.6	1.9-3.8	**Ba(Coarse)**	6.7	1.6	4.7-9.2
Co(Fine)	6.7	3.7	2.1-12.7	**Pb(Fine)**	1229	811	319-2785
Co(Coarse)	6.3	8.3	1.4-23	**Pb(Coarse)**	93	76	8-224
Cu(Fine)	345	479	25-1677				
Cu(Coarse)	78	45	23-149				

Table IV.14 Some statistics for EF with respect to Na in Site 2

Element	Average EF	Std. Dev.	Range
Mg (Fine)	0.5	0.2	0.2-0.9
Mg (Coarse)	1.7	0.8	0.8-3.7
K (Fine)	6.3	4.7	2.6-17.1
K (Coarse)	6.5	3.8	2.8-15.3

Table IV.15 Some statistics for coarse to fine EF ratios with respect to Al in Site 1

Element	Average Coarse to Fine EF Ratio	Std. Dev.	Range
Na	0.74	0.33	0.40-1.51
Mg	1.13	0.26	0.75-1.44
K	0.37	0.30	0.21-1.15
Ca	1.10	0.80	0.18-2.67
Mn	0.57	0.34	0.06-1.29
Fe	0.93	0.17	0.69-1.21
Co	1.24	1.26	0.05-3.45
Cu	0.63	0.40	0.18-1.60
Zn	0.56	0.68	0.10-1.65
Se	0.52	0.79	0.01-1.43
Mo	0.68	0.31	0.36-1.13
Cd	0.14	0.13	0.001-0.3
Sb	0.29	0.17	0.11-0.60
Ba	0.90	0.45	0.25-1.61
Pb	0.14	0.06	0.08-0.22

Table IV.16 Some statistics for coarse to fine EF ratios with respect to Na in Site 1

Element	Average Coarse to Fine EF Ratio	Std. Dev.	Range
Mg	1.67	0.46	0.95-2.24
K	0.47	0.12	0.38-0.76

Table IV.17 Some statistics for coarse to fine EF ratios with respect to Al in Site 2

Element	Average Coarse to Fine EF Ratio	Std. Dev.	Range
Na	0.42	0.65	0.09-2.25
Mg	1.32	1.51	0.26-5.20
K	0.43	0.63	0.08-2.19
Ca	3.34	1.42	1.22-5.41
Mn	0.65	0.80	0.21-2.91
Fe	0.97	0.77	0.26-2.73
Co	2.26	4.24	0.16-10.85
Cu	0.94	1.53	0.09-4.82
Zn	8.01	12.62	0.14-26.7
Se	0.78	0.09	0.72-0.88
Mo	1.50	3.70	0.03-12.01
Cd	2.62	6.90	0.05-19.71
Sb	0.25	0.11	0.09-0.42
Ba	0.82	0.86	0.29-3.19
Pb	0.18	0.21	0.04-0.76

Table IV.18 Some statistics for coarse to fine EF ratios with respect to Na in Site 2

Element	Average Coarse to Fine EF Ratio	Std. Dev.	Range
Mg	3.72	1.34	1.64-5.39
K	1.18	0.45	0.75-2.07

CHAPTER V

CONCLUDING REMARKS and RECOMMENDATIONS

In this thesis study, indoor air PM_{10} and $PM_{2.5}$ mass and elemental concentrations were determined at the Marmara University Hospital in Istanbul. Two groups of samples were collected from the children's polyclinic and the internal medicine stay patient's unit.

In children's polyclinic, samples were collected during the work hours on weekdays. The average mass concentrations obtained from the simultaneous PM_{10} and $PM_{2.5}$ measurements were 66 $\mu g/m^3$ and 24 $\mu g/m^3$, respectively. While PM_{10} concentrations ranged from 44 $\mu g/m^3$ to 98 $\mu g/m^3$, $PM_{2.5}$ concentrations ranged from 10 $\mu g/m^3$ ile 45 $\mu g/m^3$. The average, lowest, and highest PM_{10} to $PM_{2.5}$ concentration ratios were found to be 3.2, 1.7, and 6.3, respectively. The particulate matter, named coarse mode, with equivalent diameters between 2.5 μm and 10 μm has the average, lowest, and highest mass concentrations of 42 $\mu g/m^3$, 21 $\mu g/m^3$, and 57 $\mu g/m^3$, respectively. Coarse to fine ($PM_{2.5}$) ratios were calculated as 2.2, 0.7, and 5.3 for the average, lowest, and highest values, respectively. Limited number of simultaneous indoor and outdoor particulate matter measurements indicated that, the average indoor to outdoor mass concentration ratios for $PM_{2.5}$ and PM_{10} samples were 0.58 and 1.40, respectively. This result is expected to be due to the high number of visiting patients in this unit carrying coarse dust particles by their shoes into the indoor environment.

In internal medicine stay patient's unit, samples were collected for 24 hours considering that patients spend all their times in this unit. The average mass concentrations obtained from the simultaneous PM_{10} and $PM_{2.5}$ measurements were 39 $\mu g/m^3$ and 20 $\mu g/m^3$, respectively. While PM_{10} concentrations ranged from 32 $\mu g/m^3$ to 48 $\mu g/m^3$, $PM_{2.5}$ concentrations ranged from 4 $\mu g/m^3$ to 40 $\mu g/m^3$. The

average, lowest, and highest PM_{10} to $PM_{2.5}$ concentration ratios were found to be 2.5, 1.1, and 7.9, respectively. The coarse mode particulate matter has the average, lowest, and highest mass concentrations of 17 $\mu g/m^3$, 4 $\mu g/m^3$, and 30 $\mu g/m^3$, respectively. Coarse to fine ratios were calculated as 1.5, 0.1, and 6.9 for the average, lowest, and highest values, respectively. Limited number of simultaneous indoor and outdoor particulate matter measurements indicated that, the average indoor to outdoor mass concentration ratios for $PM_{2.5}$ and PM_{10} samples were 0.40 and 1.10, respectively. These ratios are lower than those of the children's polyclinic possibly due to the less patient activity and better cleaning procedures in this unit.

When the obtained results for $PM_{2.5}$ and PM_{10} mass concentrations are compared respectively to 25 $\mu g/m^3$ and 50 $\mu g/m^3$, the 24 hour limit values of World Health Organization, it is seen that both values are exceeded as much as 80 % and 100%, respectively in children's polyclinic. However, the average value for $PM_{2.5}$ mass concentrations is near the limit while that of PM_{10} is 32 % above the limit. The same comparison for the stay patient's unit indicates that both $PM_{2.5}$ and PM_{10} average mass concentrations are below the World Health Organization's limit values but $PM_{2.5}$ concentrations exceed the limit value as much as 60 % from time to time.

Elemental concentration results indicate various particulate matter sources affecting the sampling sites. These are mainly traffic and industrial emissions, crustal dust, and marine salts. Enrichment factors with respect to crust and sea salt well above 5 indicate man made emissions for many elements. The concentration values for Pb and Cd, whose limit values are defined in Turkish Air Quality Standards, are very low compared to the limit values.

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APPENDIX

APPENDIX A

ELEMENTAL CONCENTRATIONS

Table A.1 Elemental Concentrations in Site 1 [µg/m³]

Filter No	Date	Place	PM	Na	Mg	Al	K	Ca
S1	10/11/12.02.09	indoor	2.5	0.37 ± 0.024	0.08 ± 0.004	0.09 ± 0.006	0.22 ± 0.012	1.66 ± 0.122
S2	10/11/12.02.09	indoor	10	1.02 ± 0.062	0.28 ± 0.012	0.39 ± 0.020	0.39 ± 0.021	2.59 ± 0.160
S3	13/16/17.02.09	indoor	2.5	0.20 ± 0.014	0.05 ± 0.003	0.07 ± 0.005	0.23 ± 0.013	0.55 ± 0.078
S4	13/16/17.02.09	indoor	10	0.50 ± 0.031	0.20 ± 0.009	0.34 ± 0.017	0.40 ± 0.021	2.35 ± 0.151
S5	18/19/20.02.09	indoor	2.5	0.13 ± 0.009	0.05 ± 0.003	0.10 ± 0.006	0.18 ± 0.010	0.67 ± 0.082
S6	18/19/20.02.09	indoor	10	0.57 ± 0.036	0.31 ± 0.013	0.45 ± 0.022	0.41 ± 0.022	5.49 ± 0.277
S7	23/24/25.02.09	indoor	2.5	0.24 ± 0.016	0.06 ± 0.003	0.12 ± 0.007	0.28 ± 0.015	0.88 ± 0.091
S8	23/24/25.02.09	indoor	10	0.64 ± 0.040	0.26 ± 0.011	0.47 ± 0.023	0.47 ± 0.025	3.13 ± 0.182
S9	26/27.02-02.03.09	indoor	2.5	0.18 ± 0.012	0.06 ± 0.003	0.11 ± 0.007	0.24 ± 0.013	0.82 ± 0.088
S10	26/27.02-02.03.09	indoor	10	0.54 ± 0.034	0.23 ± 0.010	0.40 ± 0.020	0.42 ± 0.022	2.80 ± 0.169
S11	03/04/05.03.09	indoor	2.5	0.15 ± 0.010	0.06 ± 0.004	0.14 ± 0.008	0.29 ± 0.016	0.88 ± 0.091
S12	03/04/05.03.09	indoor	10	0.42 ± 0.028	0.26 ± 0.012	0.49 ± 0.026	0.50 ± 0.027	2.84 ± 0.200
S13	06/09/10.03.09	indoor	2.5	0.33 ± 0.021	0.35 ± 0.014	0.86 ± 0.041	0.34 ± 0.018	1.57 ± 0.119
S14	06/09/10.03.09	indoor	10	0.96 ± 0.059	0.98 ± 0.038	1.95 ± 0.092	0.84 ± 0.043	6.90 ± 0.334
S15	11/12/13.03.09	indoor	2.5	0.11 ± 0.008	0.04 ± 0.003	0.08 ± 0.005	0.19 ± 0.011	0.57 ± 0.079
S16	11/12/13.03.09	indoor	10	0.45 ± 0.030	0.32 ± 0.014	0.56 ± 0.029	0.51 ± 0.028	4.15 ± 0.255
S17	16/17/18.03.09	indoor	2.5	0.10 ± 0.007	0.06 ± 0.004	0.09 ± 0.006	0.20 ± 0.011	2.17 ± 0.143
S18	16/17/18.03.09	indoor	10	0.44 ± 0.028	0.32 ± 0.013	0.56 ± 0.027	0.48 ± 0.025	5.18 ± 0.265
S19	19/20/23.03.09	outdoor	2.5	0.08 ± 0.006	0.03 ± 0.002	0.01 ± 0.002	0.18 ± 0.010	1.66 ± 0.123
S20	19/20/23.03.09	indoor	2.5	0.12 ± 0.009	0.06 ± 0.004	0.09 ± 0.006	0.30 ± 0.016	1.74 ± 0.126
S21	24/25/26.03.09	outdoor	2.5	0.31 ± 0.020	0.05 ± 0.003	0.03 ± 0.003	0.12 ± 0.007	0.22 ± 0.064
S22	24/25/26.03.09	indoor	2.5	0.29 ± 0.019	0.06 ± 0.004	0.09 ± 0.006	0.17 ± 0.010	0.50 ± 0.076
S23	27/30/31.03.09	outdoor	10	0.21 ± 0.014	0.19 ± 0.008	0.31 ± 0.016	0.24 ± 0.013	1.41 ± 0.112
S24	27/30/31.03.09	indoor	10	0.40 ± 0.025	0.29 ± 0.012	0.57 ± 0.028	0.46 ± 0.024	3.15 ± 0.183
S25	01/02/03.04.09	outdoor	10	0.35 ± 0.022	0.20 ± 0.009	0.44 ± 0.022	0.33 ± 0.018	1.19 ± 0.103
S26	01/02/03.04.09	indoor	10	0.48 ± 0.030	0.26 ± 0.011	0.47 ± 0.023	0.46 ± 0.024	3.14 ± 0.182

Table A.1 Continued

Filter No	Mn	Fe	Co	Cu	Zn	Se
S1	4.64E-03 ± 1.59E-04	0.14 ± 0.010	3.84E-04 ± 2.79E-05	0.0107 ± 6.86E-04	0.18 ± 1.08E-02	8.17E-04 ± 3.19E-04
S2	1.14E-02 ± 3.81E-04	0.46 ± 0.026	4.51E-04 ± 3.20E-05	0.0169 ± 9.57E-04	0.06 ± 7.17E-03	3.51E-04 ± 1.37E-04
S3	4.01E-03 ± 1.38E-04	0.13 ± 0.009	2.32E-04 ± 1.87E-05	0.0097 ± 6.40E-04	0.03 ± 6.10E-03	7.33E-04 ± 2.86E-04
S4	1.16E-02 ± 3.86E-04	0.54 ± 0.030	4.02E-04 ± 2.90E-05	0.0221 ± 1.18E-03	0.04 ± 6.58E-03	1.05E-03 ± 4.10E-04
S5	8.10E-03 ± 2.72E-04	0.16 ± 0.011	5.49E-04 ± 3.80E-05	0.0061 ± 4.86E-04	0.08 ± 7.60E-03	1.24E-03 ± 4.82E-04
S6	1.82E-02 ± 6.03E-04	0.64 ± 0.035	3.56E-04 ± 2.63E-05	0.0207 ± 1.12E-03	0.12 ± 8.84E-03	6.34E-04 ± 2.47E-04
S7	4.38E-03 ± 1.50E-04	0.16 ± 0.010	1.28E-04 ± 1.24E-05	0.0115 ± 7.21E-04	0.04 ± 6.39E-03	1.26E-03 ± 4.90E-04
S8	1.36E-02 ± 4.50E-04	0.55 ± 0.030	3.65E-04 ± 2.68E-05	0.0274 ± 1.41E-03	0.18 ± 1.08E-02	4.51E-04 ± 1.76E-04
S9	5.26E-03 ± 1.79E-04	0.12 ± 0.008	6.93E-04 ± 4.68E-05	0.0068 ± 5.14E-04	0.07 ± 7.42E-03	1.11E-03 ± 4.33E-04
S10	6.09E-03 ± 2.06E-04	0.48 ± 0.027	ND	0.0147 ± 8.61E-04	0.09 ± 8.04E-03	5.28E-03 ± 2.06E-03
S11	9.60E-03 ± 3.21E-04	0.21 ± 0.013	5.27E-04 ± 3.67E-05	0.0098 ± 6.48E-04	0.10 ± 8.29E-03	9.48E-04 ± 3.70E-04
S12	1.94E-02 ± 6.62E-04	0.74 ± 0.042	2.80E-04 ± 2.41E-05	0.0283 ± 1.59E-03	0.52 ± 2.43E-02	7.65E-04 ± 2.99E-04
S13	1.20E-02 ± 3.99E-04	0.64 ± 0.035	2.94E-04 ± 2.25E-05	0.0074 ± 5.39E-04	0.38 ± 1.69E-02	6.81E-04 ± 2.66E-04
S14	3.17E-02 ± 1.04E-03	1.63 ± 0.084	8.92E-04 ± 5.89E-05	0.0223 ± 1.19E-03	0.05 ± 6.82E-03	6.33E-04 ± 2.47E-04
S15	3.59E-03 ± 1.25E-04	0.14 ± 0.009	6.19E-05 ± 8.35E-06	0.0070 ± 5.24E-04	0.03 ± 6.34E-03	4.63E-04 ± 1.81E-04
S16	1.84E-02 ± 6.28E-04	0.82 ± 0.046	5.87E-04 ± 4.32E-05	0.0344 ± 1.86E-03	0.10 ± 1.11E-02	1.91E-04 ± 7.47E-05
S17	3.97E-03 ± 1.37E-04	0.13 ± 0.009	1.78E-05 ± 5.63E-06	0.0067 ± 5.10E-04	0.22 ± 1.20E-02	6.51E-04 ± 2.54E-04
S18	1.67E-02 ± 5.52E-04	0.70 ± 0.037	3.43E-04 ± 2.55E-05	0.0247 ± 1.29E-03	0.34 ± 1.58E-02	6.77E-04 ± 2.64E-04
S19	3.10E-03 ± 1.08E-04	0.09 ± 0.007	1.68E-04 ± 1.48E-05	0.0032 ± 3.60E-04	0.24 ± 1.28E-02	5.09E-04 ± 1.99E-04
S20	4.47E-03 ± 1.53E-04	0.11 ± 0.008	6.92E-05 ± 8.78E-06	0.0059 ± 4.74E-04	0.27 ± 1.36E-02	6.08E-04 ± 2.37E-04
S21	2.29E-03 ± 8.20E-05	0.07 ± 0.006	6.26E-05 ± 8.36E-06	0.0034 ± 3.67E-04	ND	5.52E-04 ± 2.15E-04
S22	3.17E-03 ± 1.11E-04	0.14 ± 0.010	1.09E-04 ± 1.12E-05	0.0041 ± 3.97E-04	0.05 ± 6.75E-03	4.47E-04 ± 1.74E-04
S23	1.38E-02 ± 4.57E-04	0.68 ± 0.037	1.55E-04 ± 1.40E-05	0.0160 ± 9.18E-04	0.01 ± 5.64E-03	3.59E-04 ± 1.40E-04
S24	1.79E-02 ± 5.93E-04	0.78 ± 0.042	3.26E-04 ± 2.44E-05	0.0237 ± 1.25E-03	0.06 ± 7.26E-03	4.87E-04 ± 1.90E-04
S25	1.26E-02 ± 4.17E-04	0.64 ± 0.035	2.30E-04 ± 1.86E-05	0.0179 ± 9.99E-04	0.00 ± 5.32E-03	4.77E-04 ± 1.86E-04
S26	1.46E-02 ± 4.85E-04	0.65 ± 0.035	3.06E-04 ± 2.32E-05	0.0261 ± 1.36E-03	0.06 ± 7.25E-03	6.94E-04 ± 2.71E-04

Table A.1 Continued

Filter No	Mo	Cd	Sb	Ba	Pb
S1	1.71E-03 ± 1.17E-04	4.92E-04 ± 3.13E-05	1.20E-03 ± 3.86E-05	2.87E-03 ± 1.35E-04	6.68E-03 ± 3.03E-04
S2	1.09E-03 ± 7.65E-05	4.95E-04 ± 3.15E-05	1.60E-03 ± 5.17E-05	1.20E-02 ± 4.88E-04	1.05E-02 ± 4.79E-04
S3	5.30E-04 ± 3.96E-05	2.41E-04 ± 1.72E-05	7.54E-04 ± 2.43E-05	8.93E-03 ± 3.69E-04	1.04E-02 ± 4.74E-04
S4	1.41E-03 ± 9.71E-05	5.03E-04 ± 3.20E-05	1.52E-03 ± 4.89E-05	1.70E-02 ± 6.80E-04	1.33E-02 ± 6.03E-04
S5	7.49E-04 ± 5.39E-05	7.69E-04 ± 4.69E-05	1.31E-03 ± 4.22E-05	3.97E-03 ± 1.78E-04	3.11E-02 ± 1.41E-03
S6	7.28E-04 ± 5.26E-05	4.26E-04 ± 2.76E-05	1.79E-03 ± 5.78E-05	1.27E-02 ± 5.12E-04	1.59E-02 ± 7.22E-04
S7	3.06E-04 ± 2.50E-05	3.39E-04 ± 2.27E-05	9.77E-04 ± 3.15E-05	3.10E-03 ± 1.44E-04	1.17E-02 ± 5.32E-04
S8	1.16E-03 ± 8.09E-05	4.71E-04 ± 3.02E-05	2.40E-03 ± 7.73E-05	1.22E-02 ± 4.93E-04	1.77E-02 ± 8.06E-04
S9	9.36E-04 ± 6.61E-05	1.17E-03 ± 6.96E-05	1.15E-03 ± 3.72E-05	3.16E-03 ± 1.46E-04	1.01E-02 ± 4.61E-04
S10	3.73E-03 ± 2.49E-04	ND	1.67E-03 ± 5.40E-05	1.38E-02 ± 5.57E-04	8.31E-03 ± 3.78E-04
S11	4.48E-04 ± 3.42E-05	6.78E-04 ± 4.18E-05	2.01E-03 ± 6.48E-05	4.57E-03 ± 2.01E-04	2.37E-02 ± 1.08E-03
S12	1.09E-03 ± 7.95E-05	6.93E-04 ± 4.51E-05	3.71E-03 ± 1.23E-04	1.89E-02 ± 7.83E-04	2.96E-02 ± 1.37E-03
S13	6.53E-04 ± 4.76E-05	2.29E-04 ± 1.65E-05	8.82E-04 ± 2.84E-05	6.88E-03 ± 2.89E-04	9.70E-03 ± 4.41E-04
S14	6.14E-04 ± 4.50E-05	3.20E-04 ± 2.16E-05	1.56E-03 ± 5.02E-05	2.10E-02 ± 8.31E-04	1.24E-02 ± 5.63E-04
S15	3.62E-04 ± 2.86E-05	2.65E-04 ± 1.86E-05	1.11E-03 ± 3.60E-05	3.75E-03 ± 1.69E-04	1.53E-02 ± 6.95E-04
S16	1.11E-03 ± 8.10E-05	3.80E-04 ± 2.72E-05	2.65E-03 ± 8.80E-05	1.92E-02 ± 7.97E-04	2.56E-02 ± 1.19E-03
S17	1.61E-04 ± 1.54E-05	1.64E-04 ± 1.29E-05	8.72E-04 ± 2.81E-05	5.40E-03 ± 2.33E-04	1.21E-02 ± 5.52E-04
S18	6.58E-04 ± 4.80E-05	2.71E-04 ± 1.89E-05	1.90E-03 ± 6.14E-05	1.47E-02 ± 5.89E-04	1.73E-02 ± 7.86E-04
S19	3.75E-04 ± 2.95E-05	2.15E-04 ± 1.58E-05	1.11E-03 ± 3.58E-05	2.51E-03 ± 1.22E-04	1.91E-02 ± 8.68E-04
S20	2.50E-04 ± 2.13E-05	3.20E-04 ± 2.16E-05	1.10E-03 ± 3.55E-05	3.12E-03 ± 1.45E-04	1.78E-02 ± 8.09E-04
S21	4.52E-04 ± 3.45E-05	1.98E-05 ± 4.75E-06	5.34E-04 ± 1.72E-05	1.89E-03 ± 9.77E-05	7.89E-03 ± 3.59E-04
S22	3.71E-04 ± 2.92E-05	1.20E-04 ± 1.04E-05	4.34E-04 ± 1.40E-05	2.64E-03 ± 1.27E-04	5.33E-03 ± 2.42E-04
S23	8.89E-04 ± 6.31E-05	2.87E-04 ± 1.98E-05	2.04E-03 ± 6.59E-05	1.38E-02 ± 5.55E-04	1.23E-02 ± 5.61E-04
S24	8.36E-04 ± 5.96E-05	3.15E-04 ± 2.14E-05	2.07E-03 ± 6.67E-05	1.94E-02 ± 7.71E-04	1.43E-02 ± 6.51E-04
S25	8.39E-04 ± 5.98E-05	2.07E-04 ± 1.53E-05	2.53E-03 ± 8.17E-05	1.21E-02 ± 4.91E-04	1.02E-02 ± 4.62E-04
S26	7.09E-04 ± 5.13E-05	2.69E-04 ± 1.88E-05	2.14E-03 ± 6.92E-05	1.35E-02 ± 5.43E-04	1.19E-02 ± 5.43E-04

Table A.2 Elemental Concentrations in Site 2 [µg/m³]

Filter No	Date	Place	PM	Na	Mg	Al	K	Ca
S27	06.04.09	outdoor	10	1.05 ± 0.065	0.21 ± 0.009	0.24 ± 0.013	0.30 ± 0.016	3.47 ± 0.201
S28	06.04.09	indoor	10	2.03 ± 0.124	0.15 ± 0.007	0.17 ± 0.009	0.30 ± 0.016	1.65 ± 0.127
S29	07.04.09	outdoor	10	0.73 ± 0.046	0.23 ± 0.010	0.32 ± 0.017	0.41 ± 0.022	2.65 ± 0.167
S30	07.04.09	indoor	10	1.78 ± 0.109	0.17 ± 0.008	0.34 ± 0.018	0.40 ± 0.021	2.98 ± 0.181
S31	08.04.09	outdoor	2.5	0.22 ± 0.015	0.07 ± 0.004	0.13 ± 0.008	0.44 ± 0.023	1.56 ± 0.124
S32	08.04.09	indoor	2.5	0.91 ± 0.056	0.06 ± 0.004	0.17 ± 0.010	0.44 ± 0.024	1.64 ± 0.126
S33	09.04.09	outdoor	2.5	0.11 ± 0.008	0.04 ± 0.003	0.13 ± 0.008	0.30 ± 0.016	1.57 ± 0.123
S34	09.04.09	indoor	2.5	0.73 ± 0.045	0.04 ± 0.003	0.99 ± 0.047	0.30 ± 0.016	1.03 ± 0.102
S35	11.04.09	indoor	2.5	1.56 ± 0.096	0.10 ± 0.005	0.04 ± 0.004	0.18 ± 0.011	1.11 ± 0.105
S36	11.04.09	indoor	10	2.76 ± 0.168	0.22 ± 0.010	0.19 ± 0.010	0.31 ± 0.017	1.35 ± 0.115
S37	12.04.09	indoor	2.5	1.52 ± 0.096	0.08 ± 0.005	0.04 ± 0.004	0.27 ± 0.016	0.58 ± 0.113
S38	12.04.09	indoor	10	2.47 ± 0.151	0.23 ± 0.010	0.29 ± 0.015	0.42 ± 0.022	1.69 ± 0.129
S39	14.04.09	indoor	2.5	1.54 ± 0.095	0.18 ± 0.008	0.38 ± 0.020	0.25 ± 0.014	0.53 ± 0.081
S40	14.04.09	indoor	10	2.67 ± 0.162	0.49 ± 0.020	0.51 ± 0.025	0.42 ± 0.023	2.64 ± 0.167
S42	15.04.09	indoor	10	2.05 ± 0.125	0.14 ± 0.007	0.19 ± 0.011	0.31 ± 0.017	0.91 ± 0.097
S43	16.04.09	indoor	2.5	0.60 ± 0.038	0.03 ± 0.003	0.05 ± 0.004	0.25 ± 0.014	0.13 ± 0.065
S44	16.04.09	indoor	10	1.09 ± 0.067	0.15 ± 0.007	0.22 ± 0.012	0.41 ± 0.022	0.47 ± 0.079
S45	18.04.09	indoor	2.5	0.37 ± 0.024	0.04 ± 0.003	0.07 ± 0.005	0.23 ± 0.013	0.46 ± 0.079
S46	18.04.09	indoor	10	0.71 ± 0.045	0.20 ± 0.009	0.32 ± 0.017	0.42 ± 0.022	1.96 ± 0.139
S47	19.04.09	indoor	2.5	0.78 ± 0.048	0.04 ± 0.003	0.07 ± 0.005	0.24 ± 0.013	0.63 ± 0.085
S48	19.04.09	indoor	10	1.23 ± 0.076	0.15 ± 0.007	0.26 ± 0.014	0.40 ± 0.021	1.46 ± 0.119
S49	20.04.09	indoor	2.5	1.08 ± 0.067	0.05 ± 0.003	0.06 ± 0.005	0.20 ± 0.011	0.58 ± 0.084
S50	20.04.09	indoor	10	1.60 ± 0.098	0.16 ± 0.007	0.24 ± 0.013	0.32 ± 0.017	1.24 ± 0.110
S51	21.04.09	indoor	2.5	1.59 ± 0.098	0.04 ± 0.003	0.06 ± 0.005	0.17 ± 0.010	0.27 ± 0.082
S52	21.04.09	indoor	10	3.21 ± 0.195	0.29 ± 0.012	0.20 ± 0.011	0.34 ± 0.019	1.43 ± 0.118
S53	22.04.09	indoor	2.5	1.52 ± 0.093	0.11 ± 0.006	0.03 ± 0.003	0.16 ± 0.009	0.66 ± 0.087
S54	22.04.09	indoor	10	2.27 ± 0.138	0.24 ± 0.010	0.17 ± 0.010	0.31 ± 0.017	1.31 ± 0.113
S55	24.04.09	indoor	2.5	1.90 ± 0.116	0.05 ± 0.003	0.04 ± 0.004	0.18 ± 0.010	0.25 ± 0.070
S56	24.04.09	indoor	10	2.61 ± 0.159	0.13 ± 0.006	0.15 ± 0.009	0.30 ± 0.016	1.14 ± 0.106

Table A.2 Continued

Filter No	Mn	Fe	Co	Cu	Zn	Se
S27	7.80E-03 ± 2.64E-04	0.39 ± 0.022	3.98E-04 ± 2.93E-05	0.0206 ± 1.14E-03	0.10 ± 8.76E-03	4.22E-04 ± 1.65E-04
S28	6.55E-03 ± 2.23E-04	0.33 ± 0.019	2.02E-04 ± 1.73E-05	0.0154 ± 9.10E-04	ND	9.33E-04 ± 3.64E-04
S29	1.40E-02 ± 4.68E-04	0.64 ± 0.035	2.78E-04 ± 2.19E-05	0.0320 ± 1.63E-03	0.15 ± 1.05E-02	1.27E-03 ± 4.96E-04
S30	9.21E-03 ± 3.10E-04	0.47 ± 0.026	7.79E-05 ± 9.71E-06	0.0191 ± 1.07E-03	0.09 ± 8.46E-03	5.40E-04 ± 2.11E-04
S31	9.20E-03 ± 3.10E-04	0.64 ± 0.035	1.17E-04 ± 1.21E-05	0.0193 ± 1.08E-03	0.12 ± 9.62E-03	8.63E-04 ± 3.37E-04
S32	7.27E-03 ± 2.47E-04	0.38 ± 0.022	2.55E-04 ± 2.05E-05	0.0154 ± 9.10E-04	0.10 ± 8.71E-03	8.39E-04 ± 3.27E-04
S33	5.97E-03 ± 2.03E-04	0.23 ± 0.014	4.03E-06 ± 5.17E-06	0.0096 ± 6.56E-04	0.09 ± 8.34E-03	4.89E-04 ± 1.91E-04
S34	4.98E-03 ± 1.71E-04	0.16 ± 0.011	ND	0.0104 ± 6.91E-04	0.05 ± 7.40E-03	ND
S35	1.90E-03 ± 7.00E-05	0.16 ± 0.011	6.05E-05 ± 8.67E-06	0.0076 ± 5.73E-04	0.11 ± 9.04E-03	3.99E-04 ± 1.56E-04
S36	4.84E-03 ± 1.67E-04	0.36 ± 0.021	5.74E-06 ± 5.30E-06	0.0101 ± 6.81E-04	ND	3.51E-04 ± 1.37E-04
S37	2.55E-03 ± 9.78E-05	0.18 ± 0.013	ND	0.0042 ± 5.40E-04	0.00 ± 8.51E-03	1.06E-03 ± 4.15E-04
S38	6.30E-03 ± 2.15E-04	0.51 ± 0.028	3.00E-04 ± 2.33E-05	0.0101 ± 6.80E-04	0.54 ± 2.25E-02	7.33E-04 ± 2.86E-04
S39	7.72E-03 ± 2.61E-04	0.37 ± 0.021	2.48E-04 ± 2.01E-05	0.0063 ± 5.13E-04	0.02 ± 6.38E-03	6.79E-04 ± 2.65E-04
S40	1.50E-02 ± 5.00E-04	0.69 ± 0.038	1.12E-03 ± 7.34E-05	0.0161 ± 9.44E-04	0.05 ± 7.40E-03	6.15E-04 ± 2.40E-04
S42	1.00E-02 ± 3.37E-04	0.38 ± 0.022	9.80E-05 ± 1.09E-05	0.0169 ± 9.77E-04	ND	7.23E-04 ± 2.82E-04
S43	4.78E-03 ± 1.65E-04	0.11 ± 0.009	1.46E-04 ± 1.39E-05	0.0127 ± 7.91E-04	0.48 ± 2.06E-02	4.16E-04 ± 1.62E-04
S44	1.10E-02 ± 3.69E-04	0.43 ± 0.025	2.20E-04 ± 1.84E-05	0.0206 ± 1.14E-03	0.28 ± 1.44E-02	2.91E-04 ± 1.13E-04
S45	9.15E-03 ± 3.08E-04	0.26 ± 0.016	ND	0.0149 ± 8.91E-04	0.06 ± 7.43E-03	1.46E-04 ± 5.71E-05
S46	1.89E-02 ± 6.28E-04	0.76 ± 0.041	1.78E-04 ± 1.58E-05	0.0281 ± 1.47E-03	0.18 ± 1.12E-02	6.01E-04 ± 2.34E-04
S47	4.81E-03 ± 1.66E-04	0.19 ± 0.012	ND	0.0073 ± 5.58E-04	0.10 ± 8.86E-03	3.97E-04 ± 1.55E-04
S48	1.21E-02 ± 4.04E-04	0.57 ± 0.032	2.70E-03 ± 1.70E-04	0.0230 ± 1.24E-03	0.08 ± 8.28E-03	3.76E-04 ± 1.47E-04
S49	3.78E-03 ± 1.32E-04	0.15 ± 0.010	8.37E-05 ± 1.01E-05	0.0679 ± 3.21E-03	0.31 ± 1.55E-02	7.34E-04 ± 2.86E-04
S50	9.04E-03 ± 3.05E-04	0.47 ± 0.026	2.53E-04 ± 2.04E-05	0.0164 ± 9.56E-04	0.02 ± 6.47E-03	2.86E-04 ± 1.12E-04
S51	5.15E-03 ± 1.80E-04	0.72 ± 0.040	2.44E-04 ± 2.09E-05	0.0041 ± 4.61E-04	ND	6.57E-04 ± 2.56E-04
S52	7.59E-03 ± 2.57E-04	0.38 ± 0.022	3.33E-04 ± 2.53E-05	0.0179 ± 1.02E-03	0.85 ± 3.24E-02	3.30E-04 ± 1.29E-04
S53	1.73E-03 ± 6.46E-05	0.05 ± 0.005	9.25E-05 ± 1.06E-05	0.0044 ± 4.28E-04	0.20 ± 1.21E-02	5.05E-05 ± 1.97E-05
S54	5.26E-03 ± 1.81E-04	0.36 ± 0.021	1.84E-04 ± 1.62E-05	0.0065 ± 5.23E-04	0.08 ± 8.26E-03	2.01E-04 ± 7.86E-05
S55	3.00E-03 ± 1.06E-04	0.12 ± 0.009	5.30E-05 ± 8.19E-06	0.0048 ± 4.47E-04	0.07 ± 7.88E-03	4.95E-04 ± 1.93E-04
S56	6.65E-03 ± 2.26E-04	0.38 ± 0.022	2.49E-04 ± 2.02E-05	0.0108 ± 7.08E-04	0.09 ± 8.64E-03	1.42E-03 ± 5.53E-04

Table A.2 Continued

Filter No	Mo	Cd	Sb	Ba	Pb
S27	8.73E-04 ± 6.26E-05	1.62E-04 ± 1.31E-05	2.62E-03 ± 8.51E-05	9.21E-03 ± 3.83E-04	1.42E-02 ± 6.47E-04
S28	1.47E-03 ± 1.02E-04	1.56E-04 ± 1.28E-05	2.16E-03 ± 7.02E-05	7.70E-03 ± 3.24E-04	1.85E-02 ± 8.44E-04
S29	1.14E-03 ± 7.98E-05	4.04E-04 ± 2.67E-05	4.18E-03 ± 1.36E-04	1.53E-02 ± 6.20E-04	2.34E-02 ± 1.07E-03
S30	6.61E-04 ± 4.87E-05	3.47E-04 ± 2.35E-05	2.06E-03 ± 6.68E-05	1.07E-02 ± 4.40E-04	1.63E-02 ± 7.43E-04
S31	9.97E-04 ± 7.08E-05	8.21E-04 ± 5.03E-05	4.87E-03 ± 1.58E-04	2.08E-02 ± 8.32E-04	5.26E-02 ± 2.40E-03
S32	8.77E-04 ± 6.28E-05	7.96E-04 ± 4.89E-05	3.99E-03 ± 1.29E-04	1.45E-02 ± 5.86E-04	5.55E-02 ± 2.53E-03
S33	3.85E-04 ± 3.06E-05	4.24E-04 ± 2.79E-05	2.36E-03 ± 7.64E-05	4.80E-03 ± 2.13E-04	1.45E-02 ± 6.62E-04
S34	1.96E-04 ± 1.81E-05	4.50E-04 ± 2.94E-05	2.13E-03 ± 6.90E-05	3.51E-03 ± 1.63E-04	1.56E-02 ± 7.13E-04
S35	2.50E-04 ± 2.17E-05	5.47E-05 ± 7.07E-06	1.52E-03 ± 4.95E-05	2.53E-03 ± 1.25E-04	3.79E-03 ± 1.73E-04
S36	4.01E-04 ± 3.16E-05	6.39E-05 ± 7.57E-06	2.58E-03 ± 8.37E-05	7.13E-03 ± 3.03E-04	4.82E-03 ± 2.20E-04
S37	2.23E-04 ± 2.27E-05	1.04E-04 ± 1.18E-05	9.45E-04 ± 3.16E-05	2.35E-03 ± 1.33E-04	7.19E-03 ± 3.35E-04
S38	2.77E-04 ± 2.35E-05	1.77E-04 ± 1.40E-05	1.52E-03 ± 4.94E-05	8.96E-03 ± 3.73E-04	8.04E-03 ± 3.67E-04
S39	1.98E-04 ± 1.83E-05	1.46E-04 ± 1.22E-05	2.61E-03 ± 8.48E-05	5.72E-03 ± 2.48E-04	1.86E-02 ± 8.49E-04
S40	9.70E-04 ± 6.90E-05	1.70E-04 ± 1.35E-05	1.83E-03 ± 5.92E-05	1.16E-02 ± 4.77E-04	1.88E-02 ± 8.56E-04
S42	6.77E-04 ± 4.98E-05	4.95E-05 ± 6.76E-06	1.94E-03 ± 6.30E-05	8.46E-03 ± 3.54E-04	8.97E-03 ± 4.09E-04
S43	2.62E-03 ± 1.77E-04	2.27E-04 ± 1.68E-05	1.54E-03 ± 4.99E-05	3.09E-03 ± 1.47E-04	2.22E-02 ± 1.01E-03
S44	3.39E-03 ± 2.28E-04	3.10E-04 ± 2.14E-05	2.55E-03 ± 8.26E-05	9.42E-03 ± 3.91E-04	2.73E-02 ± 1.25E-03
S45	6.14E-04 ± 4.56E-05	4.53E-04 ± 2.95E-05	1.79E-03 ± 5.80E-05	6.48E-03 ± 2.78E-04	2.48E-02 ± 1.13E-03
S46	1.19E-03 ± 8.32E-05	6.72E-04 ± 4.19E-05	3.89E-03 ± 1.26E-04	1.70E-02 ± 6.85E-04	3.33E-02 ± 1.52E-03
S47	4.12E-04 ± 3.23E-05	3.32E-04 ± 2.27E-05	1.74E-03 ± 5.64E-05	4.06E-03 ± 1.84E-04	1.91E-02 ± 8.72E-04
S48	9.37E-04 ± 6.68E-05	4.53E-04 ± 2.95E-05	3.00E-03 ± 9.73E-05	1.18E-02 ± 4.82E-04	2.41E-02 ± 1.10E-03
S49	2.55E-04 ± 2.21E-05	1.62E-04 ± 1.31E-05	1.05E-03 ± 3.41E-05	5.46E-03 ± 2.38E-04	7.58E-03 ± 3.46E-04
S50	7.47E-04 ± 5.43E-05	2.81E-04 ± 1.98E-05	2.14E-03 ± 6.93E-05	1.00E-02 ± 4.14E-04	9.29E-03 ± 4.24E-04
S51	2.36E-04 ± 2.19E-05	6.73E-05 ± 8.53E-06	1.02E-03 ± 3.36E-05	2.79E-03 ± 1.41E-04	5.49E-03 ± 2.53E-04
S52	6.50E-04 ± 4.80E-05	3.00E-03 ± 1.73E-04	1.97E-03 ± 6.39E-05	8.62E-03 ± 3.60E-04	7.23E-03 ± 3.30E-04
S53	1.48E-04 ± 1.50E-05	1.65E-03 ± 9.72E-05	1.05E-03 ± 3.41E-05	1.17E-03 ± 7.23E-05	4.16E-03 ± 1.90E-04
S54	2.13E-04 ± 1.93E-05	1.24E-03 ± 7.37E-05	1.53E-03 ± 4.96E-05	4.56E-03 ± 2.03E-04	5.78E-03 ± 2.64E-04
S55	1.86E-04 ± 1.75E-05	8.11E-04 ± 4.97E-05	9.54E-04 ± 3.09E-05	3.37E-03 ± 1.57E-04	6.33E-03 ± 2.89E-04
S56	3.80E-04 ± 3.02E-05	7.34E-04 ± 4.54E-05	1.71E-03 ± 5.54E-05	6.63E-03 ± 2.83E-04	7.04E-03 ± 3.21E-04

APPENDIX B

ENRICHMENT FACTORS

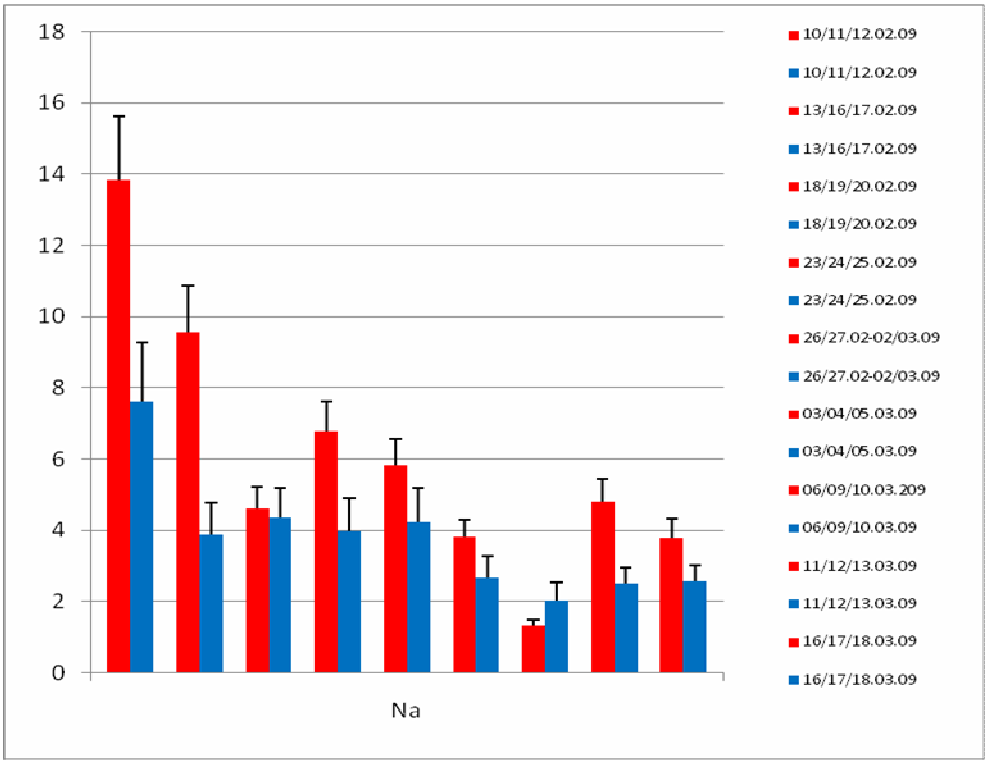
Table B.1 Enrichment Factors of Coarse and Fine fractions with respect to Aluminum in Site 1

Filter No	Date	Na	Mg	K	Ca	Mn	Fe	Co
S1	10/11/12.02.09	13.8 ± 1.8	3.1 ± 0.4	9.5 ± 1.1	35.4 ± 4.9	4.3 ± 0.4	2.3 ± 0.3	13.6 ± 1.9
C2	10/11/12.02.09	7.6 ± 1.7	2.3 ± 0.4	2.2 ± 0.6	6.3 ± 2.4	2.0 ± 0.3	1.5 ± 0.3	0.7 ± 0.7
S3	13/16/17.02.09	9.6 ± 1.3	2.2 ± 0.3	12.1 ± 1.5	14.6 ± 3.1	4.7 ± 0.5	2.6 ± 0.4	10.3 ± 1.5
C4	13/16/17.02.09	3.9 ± 0.9	2.0 ± 0.3	2.5 ± 0.7	13.4 ± 2.8	2.5 ± 0.4	2.2 ± 0.4	2.1 ± 0.8
S5	18/19/20.02.09	4.6 ± 0.6	1.8 ± 0.2	6.9 ± 0.8	13.2 ± 2.4	6.9 ± 0.7	2.3 ± 0.3	17.8 ± 2.3
C6	18/19/20.02.09	4.4 ± 0.8	2.6 ± 0.4	2.6 ± 0.6	27.4 ± 4.3	2.5 ± 0.4	2.0 ± 0.4	ND
S7	23/24/25.02.09	6.8 ± 0.8	1.6 ± 0.2	8.9 ± 1.0	14.0 ± 2.3	3.0 ± 0.3	1.8 ± 0.2	3.4 ± 0.5
C8	23/24/25.02.09	4.0 ± 0.9	2.1 ± 0.3	2.1 ± 0.6	12.9 ± 2.7	2.3 ± 0.4	1.7 ± 0.3	2.2 ± 0.6
S9	26/27.02-02.03.09	5.8 ± 0.7	1.8 ± 0.2	8.6 ± 1.0	14.6 ± 2.5	4.1 ± 0.4	1.5 ± 0.2	20.6 ± 2.7
C10	26/27.02-02.03.09	4.2 ± 0.9	2.1 ± 0.4	2.4 ± 0.7	13.6 ± 3.0	0.2 ± 0.1	1.8 ± 0.3	ND
S11	03/04/05.03.09	3.8 ± 0.5	1.6 ± 0.2	8.4 ± 0.9	12.7 ± 2.1	6.1 ± 0.6	2.3 ± 0.3	12.7 ± 1.6
C12	03/04/05.03.09	2.7 ± 0.6	2.0 ± 0.3	2.3 ± 0.7	11.0 ± 2.7	2.4 ± 0.5	2.2 ± 0.4	ND
S13	06/09/10.03.209	1.3 ± 0.2	1.4 ± 0.1	1.6 ± 0.2	3.6 ± 0.4	1.2 ± 0.1	1.1 ± 0.1	1.1 ± 0.1
C14	06/09/10.03.09	2.0 ± 0.5	2.0 ± 0.4	1.8 ± 0.4	9.7 ± 2.0	1.6 ± 0.3	1.3 ± 0.3	1.8 ± 0.5
S15	11/12/13.03.09	4.8 ± 0.7	1.8 ± 0.2	9.2 ± 1.1	13.8 ± 2.8	3.8 ± 0.4	2.4 ± 0.3	2.5 ± 0.5
C16	11/12/13.03.09	2.5 ± 0.5	2.1 ± 0.3	2.6 ± 0.5	15.0 ± 2.5	2.7 ± 0.3	2.1 ± 0.3	3.6 ± 0.6
S17	16/17/18.03.09	3.8 ± 0.5	2.4 ± 0.3	8.8 ± 1.1	48.5 ± 6.3	3.9 ± 0.4	2.1 ± 0.3	0.7 ± 0.3
C18	16/17/18.03.09	2.6 ± 0.4	1.9 ± 0.3	2.3 ± 0.5	12.8 ± 2.6	2.4 ± 0.3	1.8 ± 0.3	2.3 ± 0.4

S: fine particles C: coarse particles

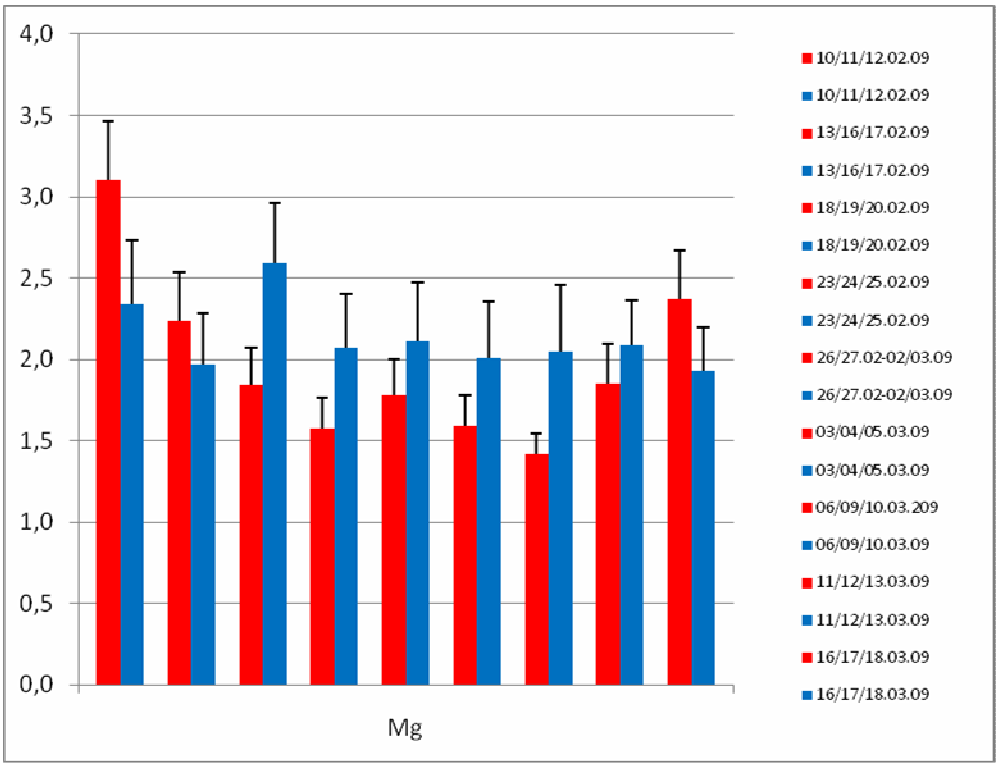
Table B.1 Continued

FilterNo	Cu	Zn	Se	Mo	Cd	Sb	Ba	Pb
S1	173.0 ± 22.1	2282.9 ± 283.1	14474.7 ± 6569.7	1008.9 ± 133.4	2180.2 ± 278.1	5297.6 ± 509.5	6.0 ± 0.7	472.6 ± 51.7
C2	31.3 ± 11.0	ND	ND	ND	3.6 ± 87.5	561.3 ± 173.5	6.0 ± 0.9	85.8 ± 24.8
S3	194.0 ± 26.2	422.0 ± 125.3	16188.9 ± 7422.7	390.4 ± 55.9	1331.5 ± 186.4	4165.0 ± 419.9	23.2 ± 2.5	920.3 ± 105.0
C4	69.9 ± 16.1	70.9 ± 61.9	1962.8 ± 4460.8	181.0 ± 43.4	405.2 ± 110.2	1177.0 ± 212.4	5.9 ± 1.3	70.3 ± 32.5
S5	90.9 ± 12.8	886.2 ± 143.6	20080.5 ± 9084.4	405.9 ± 54.5	3122.7 ± 385.4	5311.0 ± 502.9	7.6 ± 0.8	2018.0 ± 217.9
C6	62.3 ± 12.0	131.7 ± 66.3	ND	ND	ND	573.4 ± 165.4	4.8 ± 0.8	ND
S7	138.4 ± 16.9	339.7 ± 80.6	16618.9 ± 7470.0	135.0 ± 19.0	1120.7 ± 141.9	3230.2 ± 296.5	4.8 ± 0.5	618.3 ± 65.0
C8	68.7 ± 15.3	489.5 ± 102.0	ND	135.6 ± 28.8	157.3 ± 76.8	1688.0 ± 279.3	5.1 ± 0.8	114.7 ± 35.6
S9	92.0 ± 12.6	749.4 ± 124.7	16540.5 ± 7460.3	464.8 ± 61.2	4366.4 ± 525.9	4297.5 ± 401.1	5.5 ± 0.6	603.2 ± 64.3
C10	41.0 ± 10.9	78.1 ± 69.9	23635.2 ± 16318.8	527.3 ± 108.4	ND	735.8 ± 197.5	7.1 ± 1.1	ND
S11	108.0 ± 13.4	837.1 ± 120.4	11454.7 ± 5135.4	180.3 ± 24.3	2048.7 ± 245.9	6071.3 ± 550.2	6.5 ± 0.7	1145.6 ± 119.0
C12	77.8 ± 16.8	1385.0 ± 238.9	ND	98.8 ± 26.9	17.7 ± 102.4	1968.7 ± 403.8	7.8 ± 1.3	109.0 ± 55.8
S13	12.8 ± 1.6	515.4 ± 47.9	1304.2 ± 571.2	41.7 ± 5.0	109.7 ± 13.2	422.1 ± 33.9	1.5 ± 0.1	74.3 ± 6.9
C14	20.5 ± 4.9	ND	ND	ND	34.1 ± 18.5	254.1 ± 60.5	2.5 ± 0.5	16.2 ± 8.0
S15	127.2 ± 18.0	494.6 ± 123.8	9295.1 ± 4242.7	241.9 ± 35.2	1329.9 ± 181.6	5590.6 ± 552.0	8.8 ± 1.0	1225.6 ± 137.3
C16	86.6 ± 13.7	160.6 ± 54.7	ND	86.4 ± 18.9	99.8 ± 46.9	1328.4 ± 203.0	6.3 ± 0.8	143.6 ± 36.5
S17	113.2 ± 16.0	2908.3 ± 348.4	12111.7 ± 5508.0	99.8 ± 16.0	764.0 ± 109.4	4053.9 ± 393.5	11.8 ± 1.3	902.6 ± 99.6
C18	57.5 ± 9.8	302.4 ± 91.3	90.6 ± 1828.1	58.3 ± 11.5	93.5 ± 34.5	906.8 ± 142.7	3.8 ± 0.6	72.2 ± 23.9



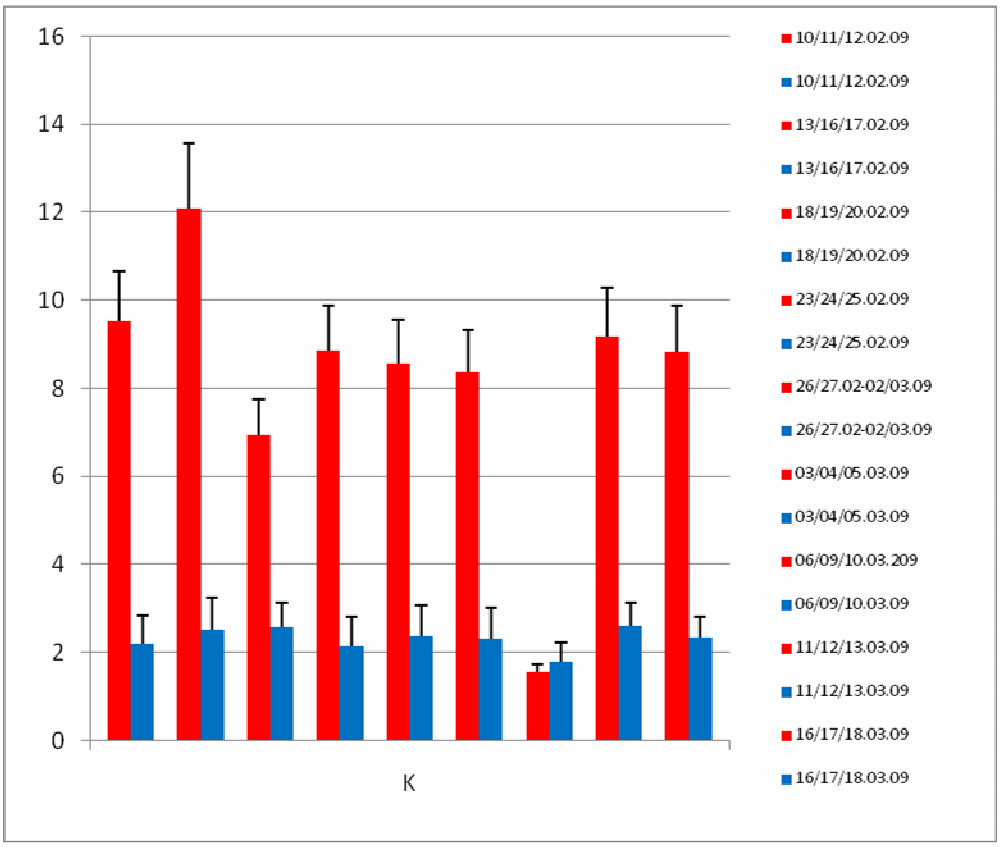
Red:Fine Particles Blue: Coarse Particles

Figure B.1 EF of Na with respect to Al for Fine and Coarse fractions in Site 1



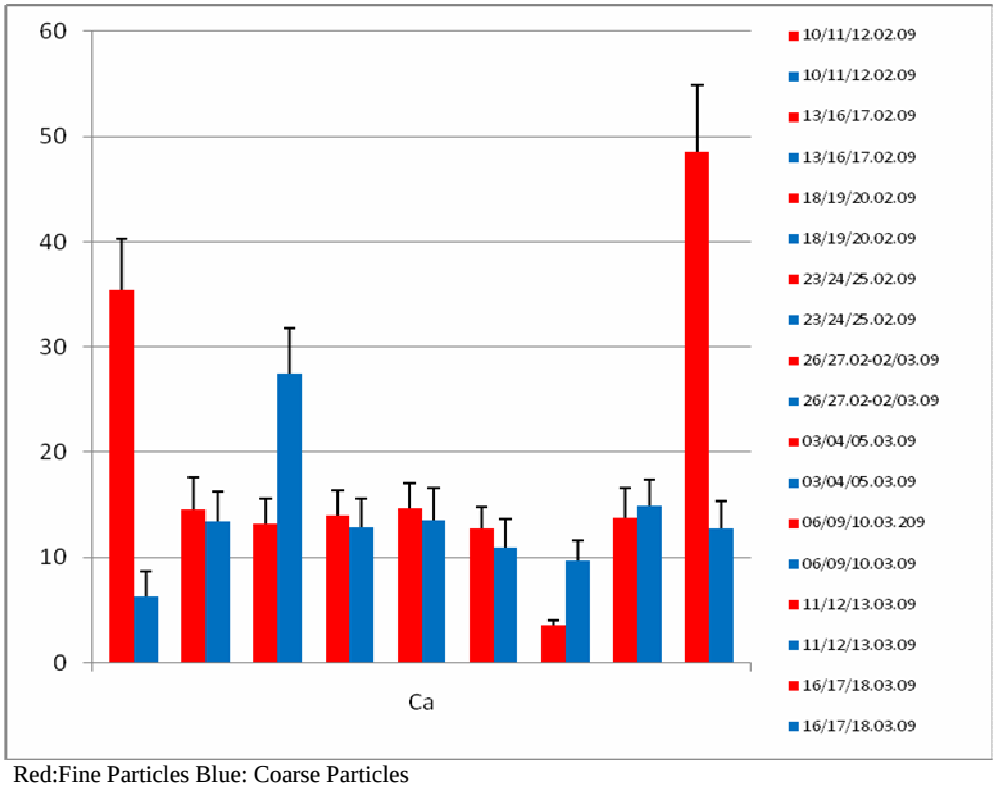
Red:Fine Particles Blue: Coarse Particles

Figure B.2 EF of Mg with respect to Al for Fine and Coarse fractions in Site 1



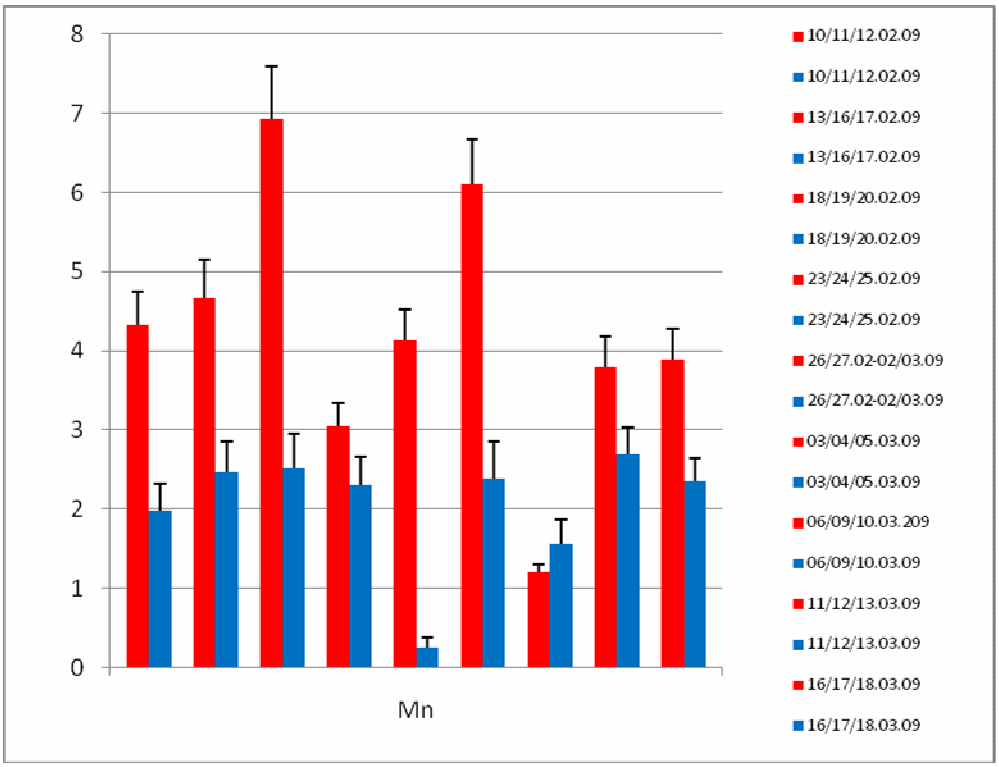
Red:Fine Particles Blue: Coarse Particles

Figure B.3 EF of K with respect to Al for Fine and Coarse fractions in Site 1



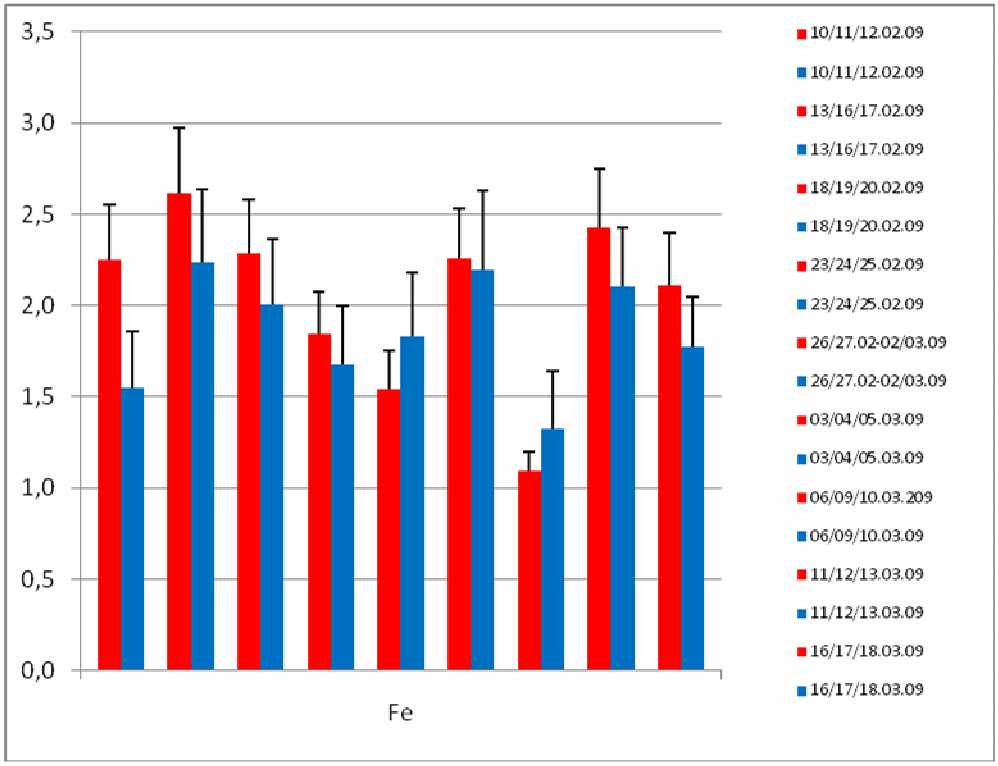
Red:Fine Particles Blue: Coarse Particles

Figure B.4 EF of Ca with respect to Al for Fine and Coarse fractions in Site 1



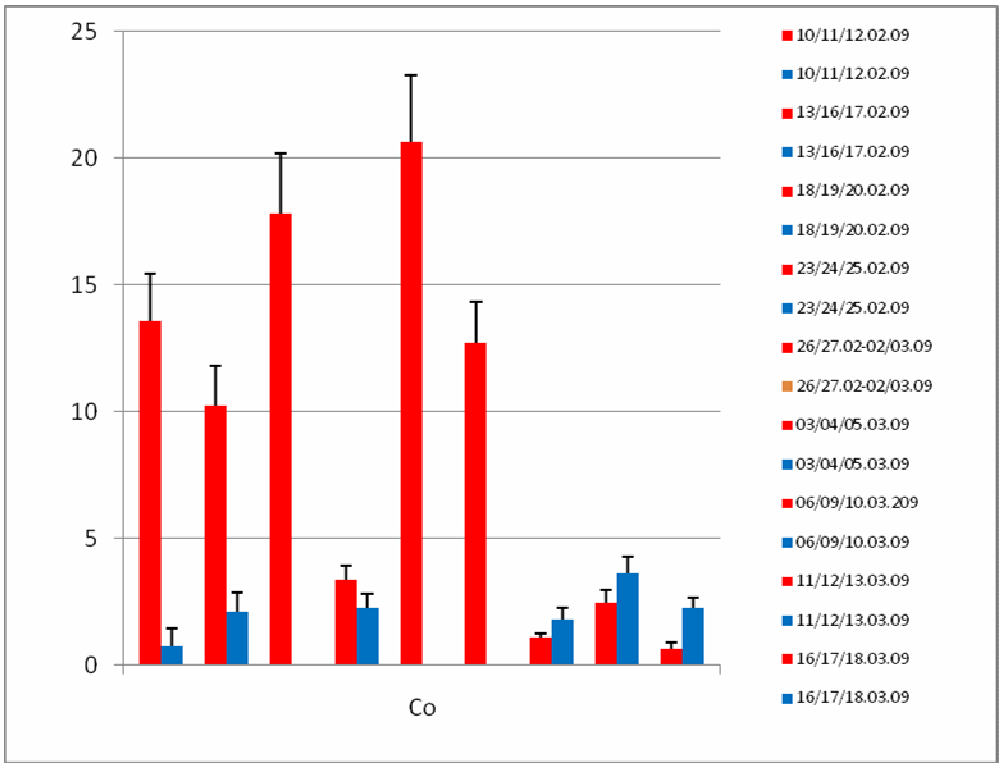
Red:Fine Particles Blue: Coarse Particles

Figure B.5 EF of Mn with respect to Al for Fine and Coarse fractions in Site 1



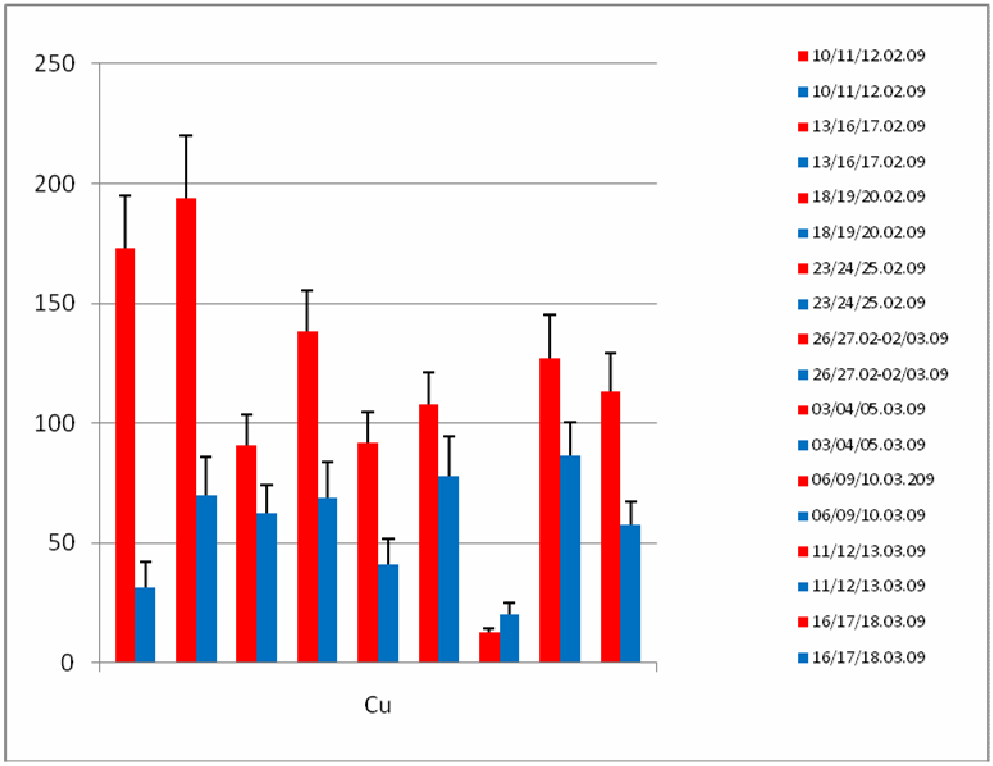
Red:Fine Particles Blue: Coarse Particles

Figure B.6 EF of Fe with respect to Al for Fine and Coarse fractions in Site 1



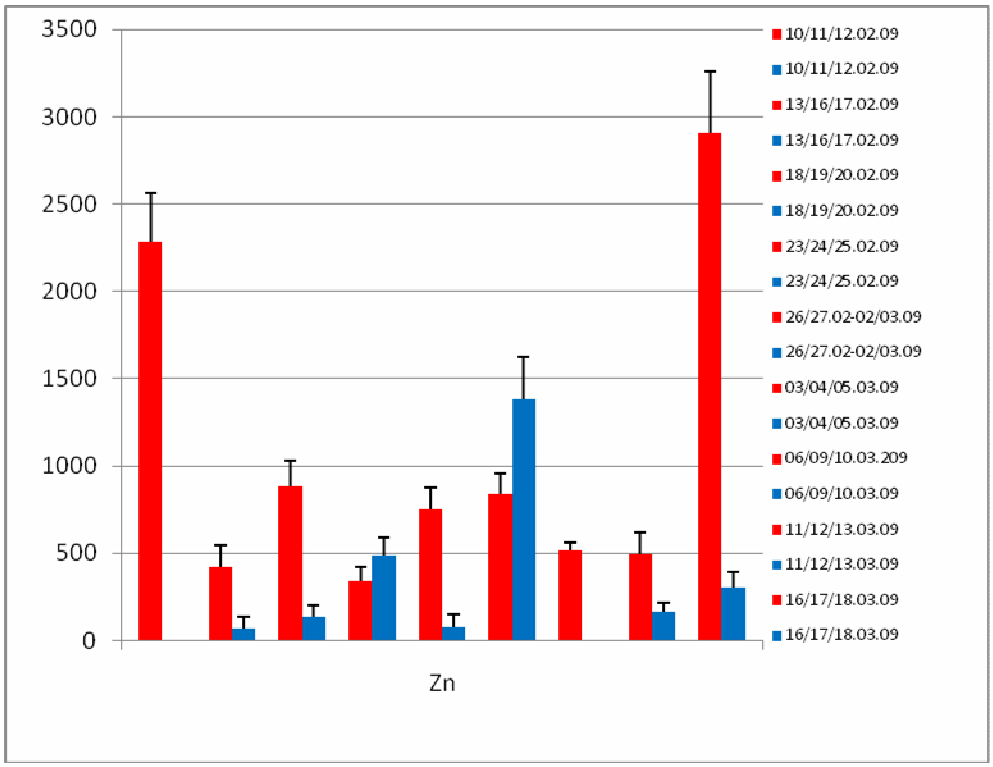
Red:Fine Particles Blue: Coarse Particles

Figure B.7 EF of Co with respect to Al for Fine and Coarse fractions in Site 1



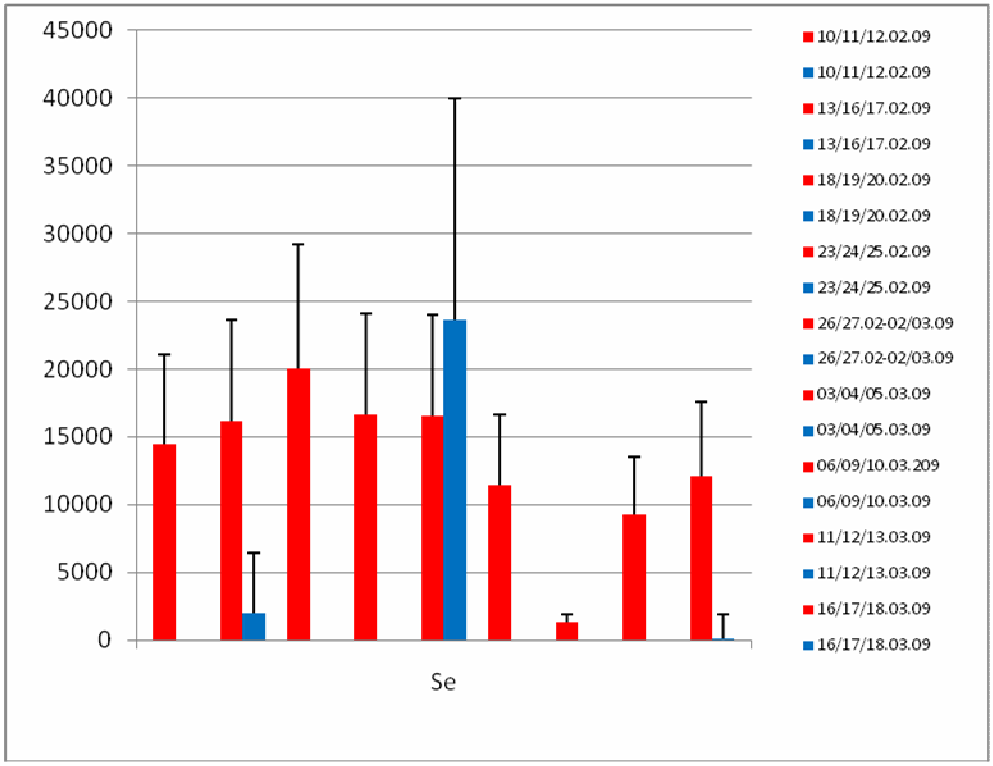
Red:Fine Particles Blue: Coarse Particles

Figure B.8 EF of Cu with respect to Al for Fine and Coarse fractions in Site 1



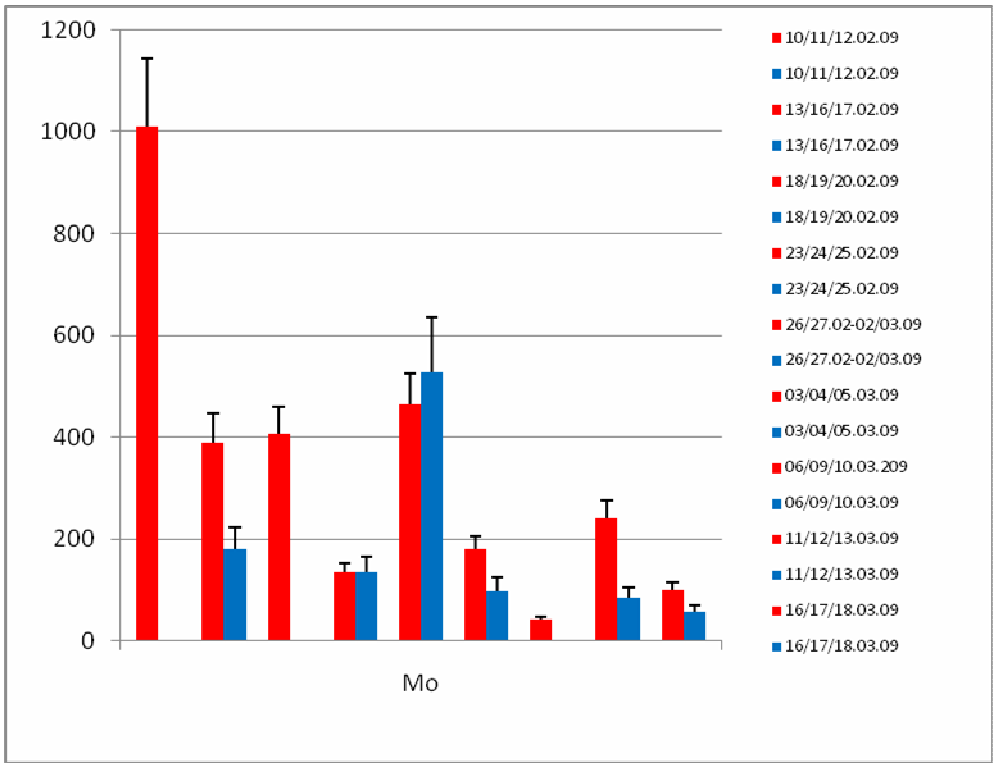
Red:Fine Particles Blue: Coarse Particles

Figure B.9 EF of Zn with respect to Al for Fine and Coarse fractions in Site 1



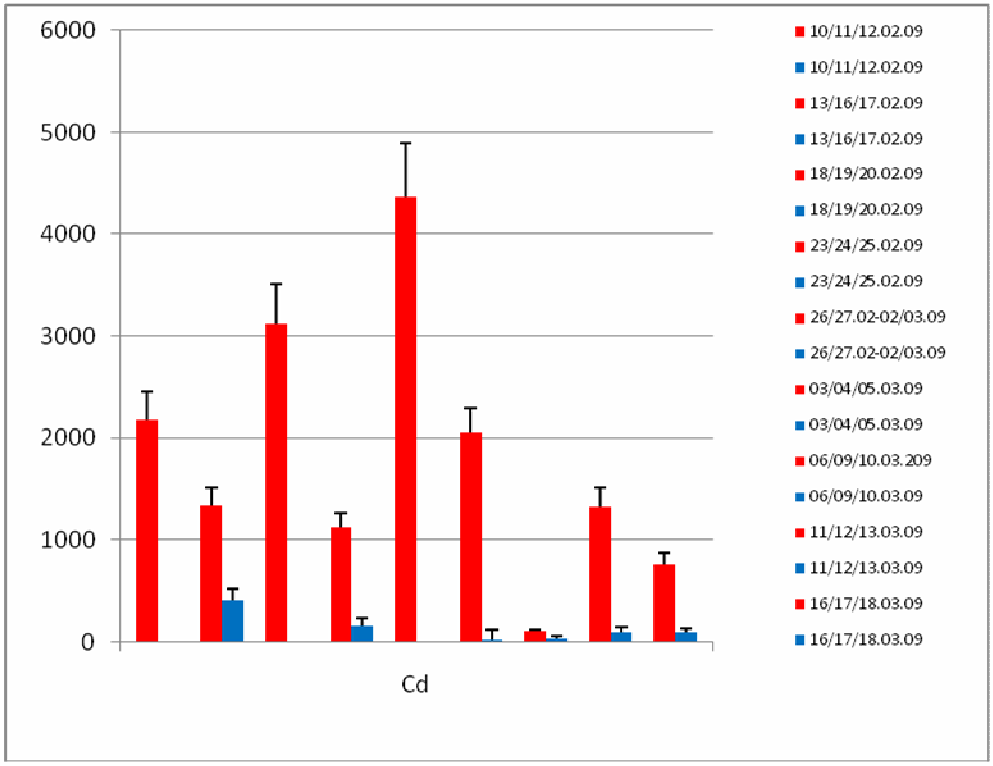
Red:Fine Particles Blue: Coarse Particles

Figure B.10 EF of Se with respect to Al for Fine and Coarse fractions in Site 1



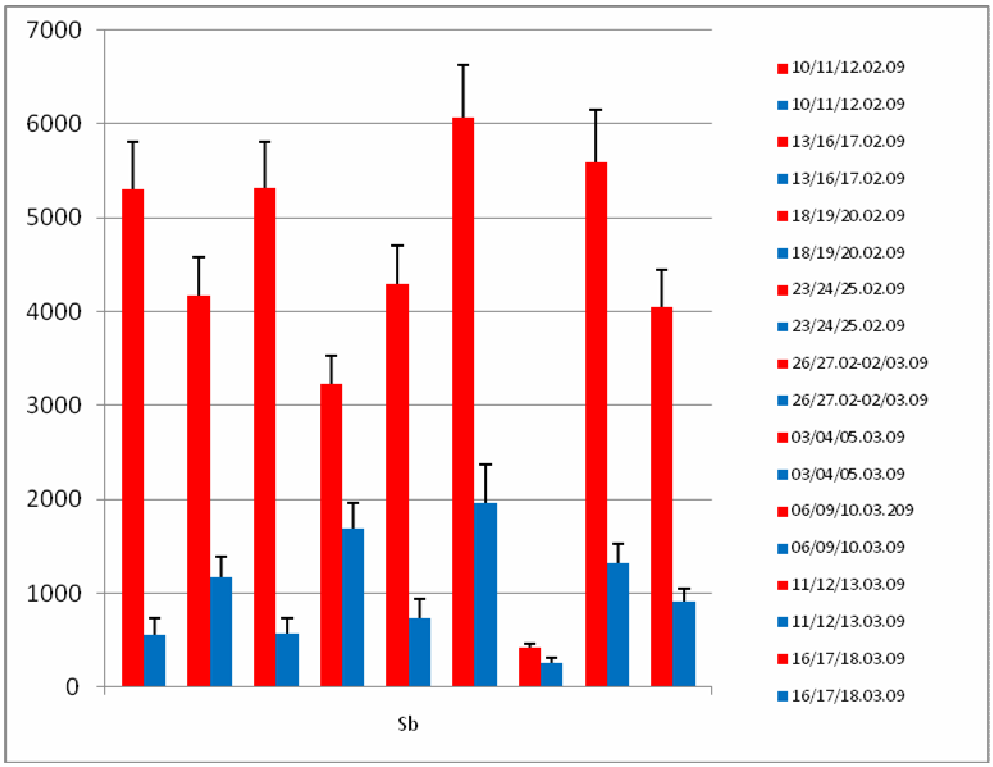
Red:Fine Particles Blue: Coarse Particles

Figure B.11 EF of Mo with respect to Al for Fine and Coarse fractions in Site 1



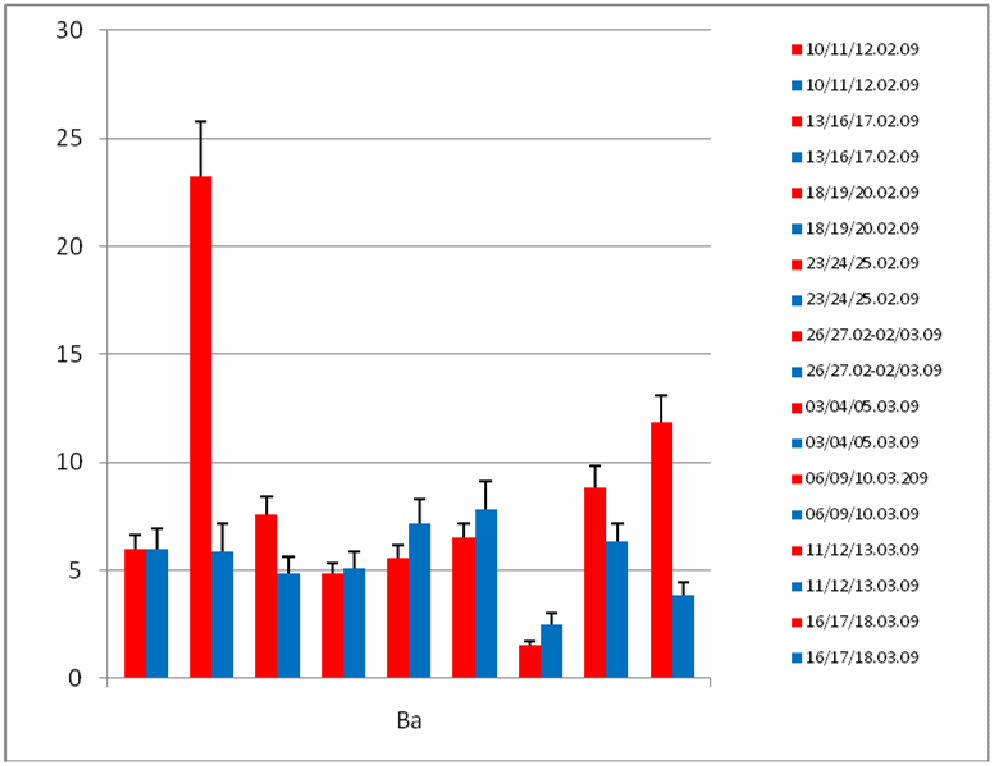
Red:Fine Particles Blue: Coarse Particles

Figure B.12 EF of Cd with respect to Al for Fine and Coarse fractions in Site 1



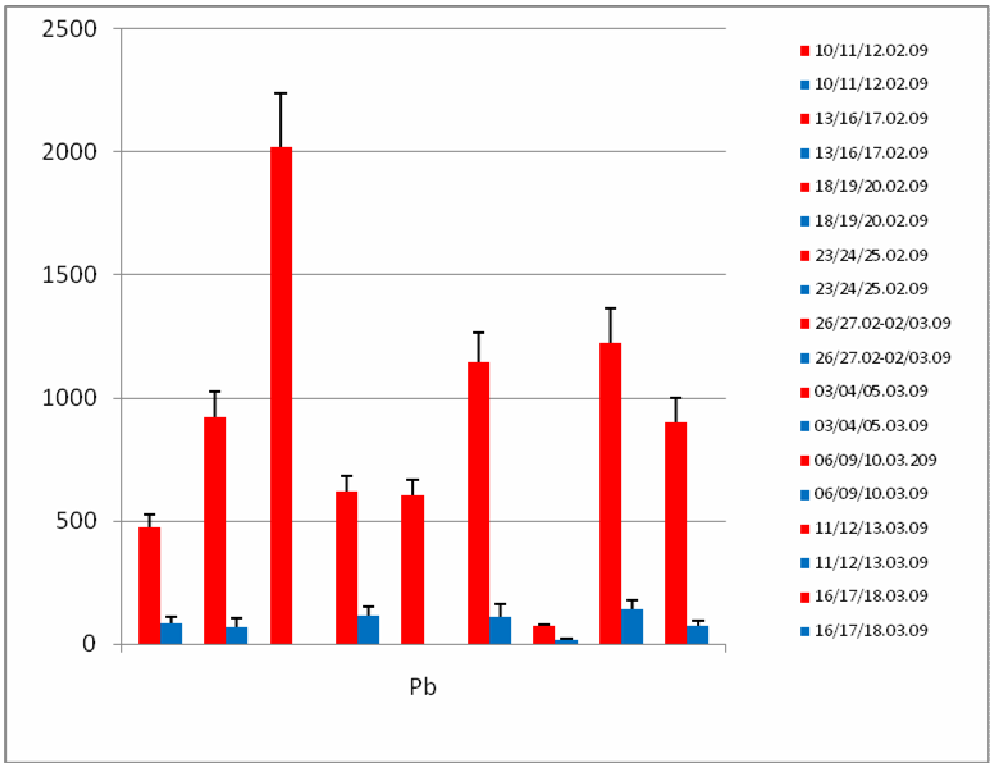
Red:Fine Particles Blue: Coarse Particles

Figure B.13 EF of Sb with respect to Al for Fine and Coarse fractions in Site 1



Red:Fine Particles Blue: Coarse Particles

Figure B.14 EF of Ba with respect to Al for Fine and Coarse fractions in Site 1



Red:Fine Particles Blue: Coarse Particles

Figure B.15 EF of Pb with respect to Al for Fine and Coarse fractions in Site 1

Table B.2 Enrichment Factors of Coarse and Fine fractions with respect to Aluminum in Site 2

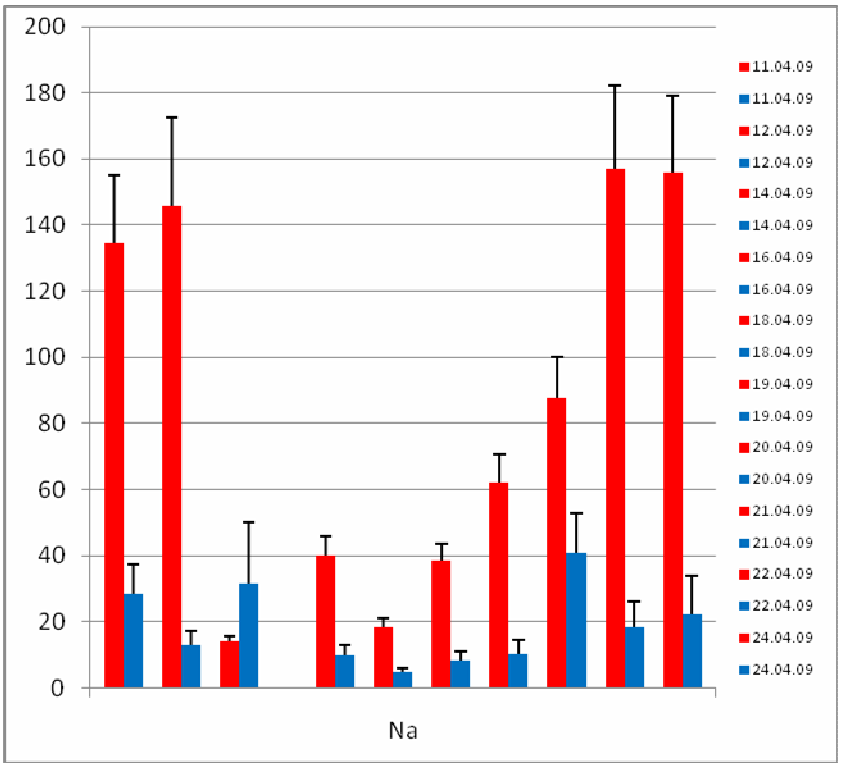
Filter No	Date	Na	Mg	Al	K	Ca	Mn	Fe	Co
S35	11.04.09	134.5 ± 20.5	8.6 ± 1.2	1 ± 0.2	17.9 ± 2.7	54.3 ± 10.1	4.1 ± 0.5	5.7 ± 0.9	4.9 ± 1.2
C36	11.04.09	28.5 ± 9.0	3.0 ± 0.6	1 ± 0.2	3.3 ± 1.0	3.3 ± 3.3	1.7 ± 0.3	2.1 ± 0.5	ND
S37	12.04.09	145.8 ± 26.7	7.9 ± 1.5	1 ± 0.2	29.1 ± 5.2	31.8 ± 10.0	6.1 ± 1.0	7.2 ± 1.4	ND
C38	12.04.09	13.0 ± 4.4	2.1 ± 0.4	1 ± 0.2	2.3 ± 0.8	8.6 ± 2.5	1.3 ± 0.2	1.9 ± 0.4	ND
S39	14.04.09	14.0 ± 1.6	1.7 ± 0.2	1 ± 0.1	2.5 ± 0.3	2.7 ± 0.6	1.7 ± 0.1	1.4 ± 0.2	2.1 ± 0.3
C40	14.04.09	31.5 ± 18.5	8.7 ± 3.9	1 ± 0.7	5.6 ± 3.2	33.6 ± 16.1	5.1 ± 2.4	3.8 ± 2.1	23.0 ± 10.8
S43	16.04.09	40.1 ± 5.8	2.2 ± 0.4	1 ± 0.2	19.1 ± 2.6	4.8 ± 2.9	7.9 ± 0.9	3.2 ± 0.5	9.2 ± 1.6
C44	16.04.09	10.0 ± 3.1	2.4 ± 0.4	1 ± 0.2	3.6 ± 1.2	4.0 ± 2.1	3.2 ± 0.6	2.7 ± 0.5	1.4 ± 0.8
S45	18.04.09	18.4 ± 2.5	2.2 ± 0.3	1 ± 0.1	12.8 ± 1.6	13.0 ± 3.1	11.2 ± 1.2	5.4 ± 0.7	ND
C46	18.04.09	4.7 ± 1.4	2.3 ± 0.4	1 ± 0.2	3.0 ± 0.8	11.8 ± 2.8	3.4 ± 0.6	2.9 ± 0.6	ND
S47	19.04.09	38.5 ± 5.2	1.9 ± 0.3	1 ± 0.1	13.2 ± 1.7	17.6 ± 3.7	5.9 ± 0.6	4.0 ± 0.5	ND
C48	19.04.09	8.2 ± 3.0	2.1 ± 0.4	1 ± 0.2	3.2 ± 1.0	8.6 ± 2.9	3.3 ± 0.6	2.9 ± 0.6	ND
S49	20.04.09	62.1 ± 8.6	2.9 ± 0.4	1 ± 0.2	12.7 ± 1.7	19.0 ± 4.2	5.4 ± 0.6	3.5 ± 0.5	4.5 ± 0.9
C50	20.04.09	10.3 ± 4.3	2.2 ± 0.4	1 ± 0.2	2.7 ± 0.9	7.4 ± 2.9	2.6 ± 0.5	2.7 ± 0.6	3.1 ± 0.9
S51	21.04.09	87.7 ± 12.5	2.5 ± 0.4	1 ± 0.2	10.3 ± 1.5	8.3 ± 3.3	7.1 ± 0.8	16.7 ± 2.3	12.7 ± 2.1
C52	21.04.09	40.7 ± 12.1	6.3 ± 1.1	1 ± 0.2	5.0 ± 1.4	16.7 ± 4.8	1.5 ± 0.4	ND	2.1 ± 1.3
S53	22.04.09	156.9 ± 25.3	11.9 ± 1.8	1 ± 0.2	18.1 ± 2.9	38.8 ± 9.0	4.4 ± 0.6	2.0 ± 0.4	9.0 ± 1.9
C54	22.04.09	18.5 ± 7.5	3.1 ± 0.7	1 ± 0.2	4.4 ± 1.2	9.1 ± 3.7	2.2 ± 0.4	3.3 ± 0.6	2.2 ± 0.8
S55	24.04.09	155.7 ± 23.3	4.1 ± 0.6	1 ± 0.2	16.3 ± 2.4	11.8 ± 4.3	6.1 ± 0.8	4.1 ± 0.7	4.1 ± 1.0
C56	24.04.09	22.4 ± 11.3	2.6 ± 0.6	1 ± 0.2	4.4 ± 1.5	16.0 ± 5.0	2.9 ± 0.6	3.5 ± 0.8	5.9 ± 1.5

S: fine particles C: coarse particles

Table B.2 Continued

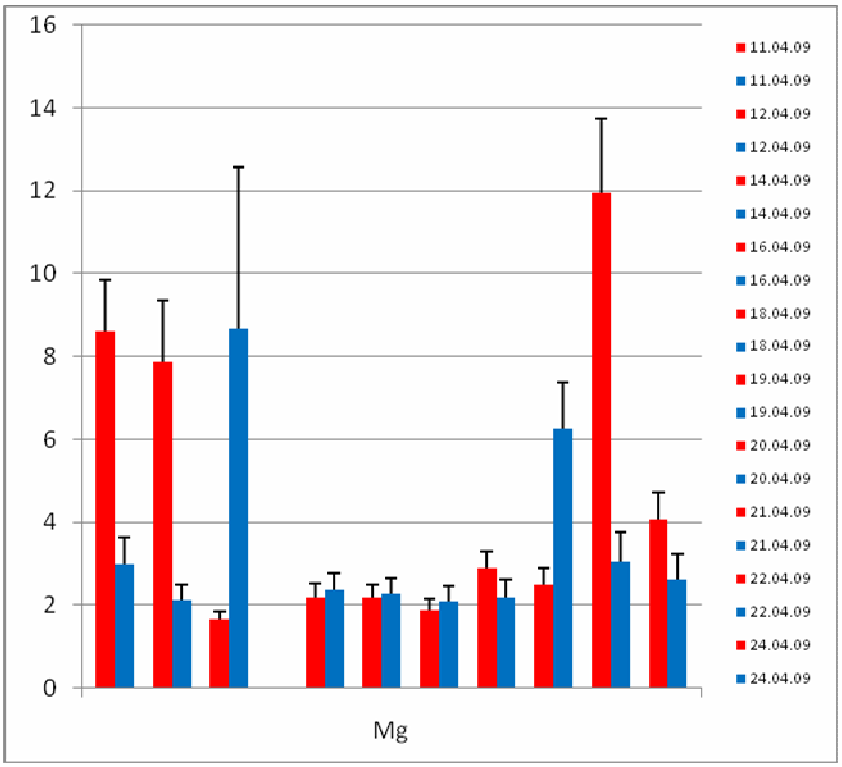
FilterNo	Cu	Zn	Se	Mo	Cd	Sb	Ba	Pb
S35	282.8 ± 47.0	3086.6 ± 544.4	16251.2 ± 7821.8	339.5 ± 60.5	556.5 ± 122.7	15519.1 ± 1918.2	12.1 ± 1.7	616.5 ± 84.4
C36	25.5 ± 15.2	ND	ND	56.3 ± 25.4	25.7 ± 43.5	2964.7 ± 659.5	6.1 ± 1.1	46.3 ± 22.1
S37	173.8 ± 43.2	91.9 ± 286.1	48024.1 ± 24581.3	335.5 ± 74.7	1175.5 ± 275.7	10684.5 ± 1647.1	12.5 ± 2.2	1298.9 ± 217.5
C38	34.5 ± 9.8	2454.5 ± 331.8	ND	11.7 ± 10.8	117.8 ± 50.6	931.0 ± 202.2	5.0 ± 0.8	22.1 ± 19.8
S39	24.6 ± 3.3	67.2 ± 23.0	2911.4 ± 1284.1	28.3 ± 4.1	156.0 ± 21.0	2800.8 ± 233.5	2.9 ± 0.3	318.5 ± 30.8
C40	118.4 ± 60.2	308.0 ± 241.3	ND	340.3 ± 161.2	78.9 ± 113.5	ND	9.2 ± 4.4	8.1 ± 93.1
S43	362.2 ± 51.9	10737.2 ± 1331.2	13088.6 ± 6163.5	2748.3 ± 407.9	1784.0 ± 275.9	12085.2 ± 1368.1	11.4 ± 1.5	2785.0 ± 352.3
C44	69.5 ± 23.6	ND	ND	246.3 ± 153.9	200.0 ± 111.3	2435.1 ± 552.8	7.2 ± 1.3	199.0 ± 106.2
S45	316.0 ± 41.5	918.4 ± 189.3	3405.1 ± 1572.9	476.1 ± 69.5	2633.9 ± 360.7	10394.7 ± 1083.2	17.7 ± 2.0	2302.8 ± 270.6
C46	79.1 ± 21.0	567.8 ± 136.9	2991.2 ± 2179.3	125.6 ± 39.2	360.2 ± 148.9	3460.0 ± 603.8	8.2 ± 1.5	223.8 ± 89.2
S47	155.5 ± 23.0	1687.4 ± 269.1	9263.1 ± 4279.7	320.5 ± 48.2	1934.7 ± 271.4	10148.8 ± 1058.6	11.1 ± 1.3	1783.4 ± 209.7
C48	121.5 ± 25.9	ND	ND	149.2 ± 42.9	258.2 ± 136.6	2688.2 ± 592.5	7.7 ± 1.4	169.5 ± 83.9
S49	1677.1 ± 206.7	6084.0 ± 763.6	19922.6 ± 9287.9	231.1 ± 37.5	1100.5 ± 172.7	7144.8 ± 775.2	17.4 ± 2.1	822.8 ± 100.2
C50	ND	ND	ND	152.1 ± 38.6	275.2 ± 103.5	2515.3 ± 487.2	5.0 ± 1.2	63.3 ± 34.8
S51	96.7 ± 18.8	ND	17148.1 ± 8080.5	205.3 ± 35.6	439.3 ± 91.1	6691.6 ± 759.6	8.6 ± 1.1	572.9 ± 72.7
C52	148.8 ± 33.3	ND	ND	163.3 ± 46.6	8657.2 ± 1546.4	2789.6 ± 613.4	8.1 ± 1.6	82.1 ± 37.1
S53	192.5 ± 38.1	7082.5 ± 1125.5	2454.2 ± 1202.1	239.7 ± 48.2	20100.1 ± 3185.9	12792.5 ± 1690.0	6.7 ± 1.1	808.6 ± 117.6
C54	23.4 ± 12.4	ND	1775.8 ± 1323.8	25.6 ± 15.9	ND	1403.0 ± 378.7	4.7 ± 0.8	76.0 ± 28.5
S55	168.5 ± 30.6	1930.1 ± 388.8	19139.9 ± 9164.5	239.8 ± 43.8	7829.5 ± 1174.5	9217.1 ± 1116.4	15.3 ± 2.1	976.9 ± 131.3
C56	81.7 ± 25.2	260.7 ± 207.5	13869.5 ± 12819.3	96.9 ± 35.1	ND	2829.1 ± 650.3	5.8 ± 1.4	43.0 ± 41.6

S: fine particles C: coarse particles



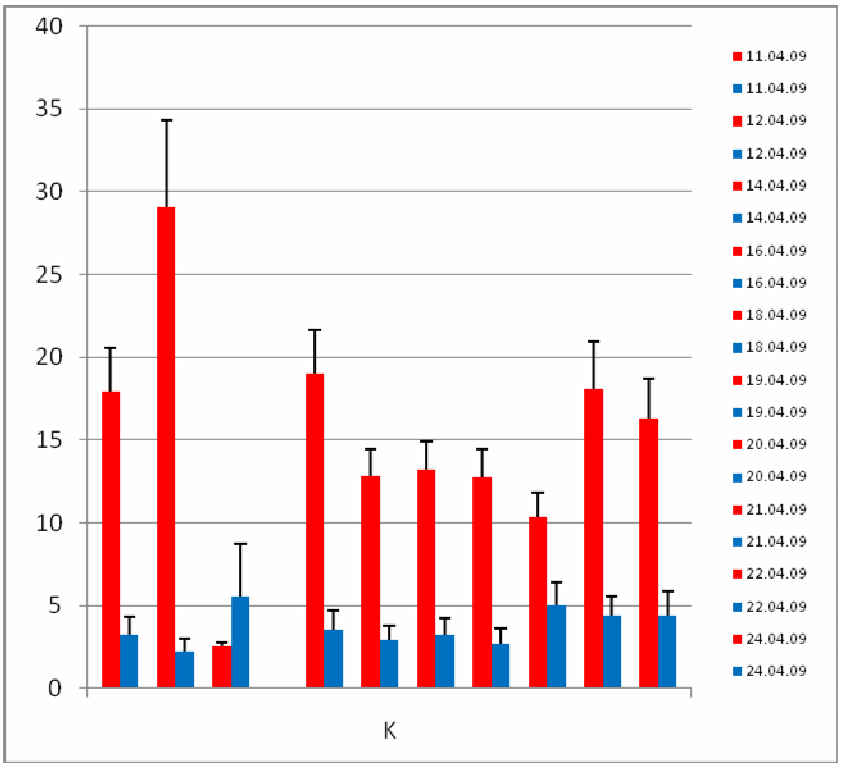
Red:Fine Particles Blue: Coarse Particles

Figure B.16 EF of Na with respect to Al for Fine and Coarse fractions in Site 2



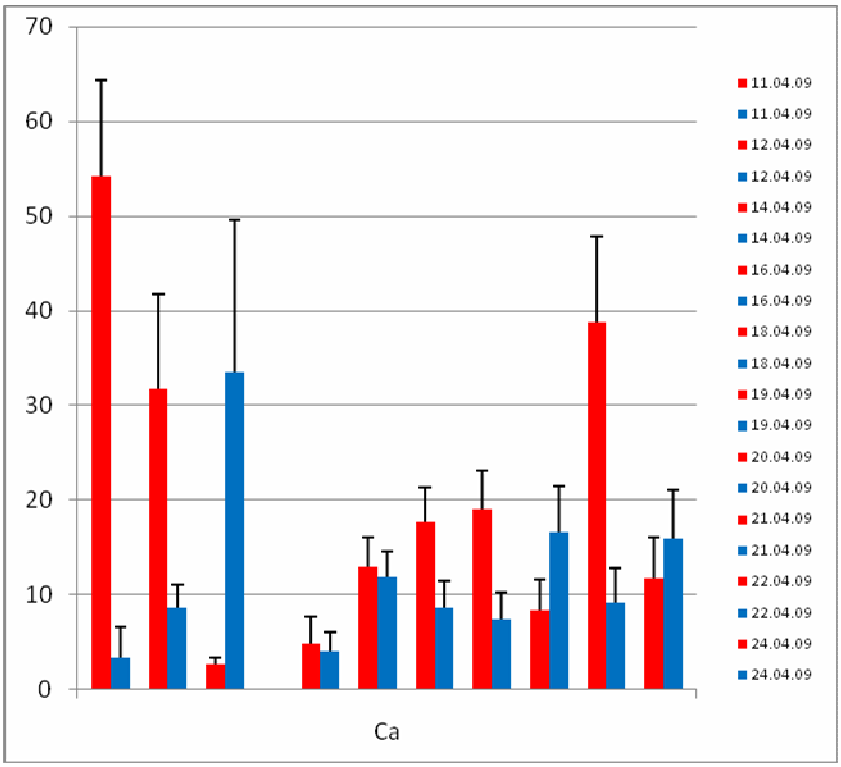
Red:Fine Particles Blue: Coarse Particles

Figure B.17 EF of Mg with respect to Al for Fine and Coarse fractions in Site 2



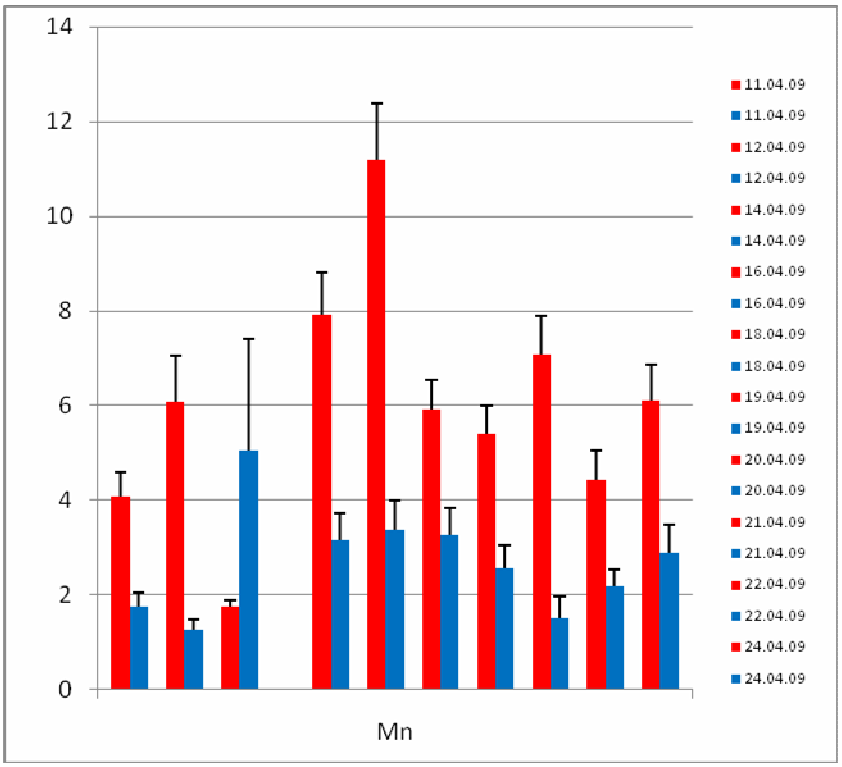
Red:Fine Particles Blue: Coarse Particles

Figure B.18 EF of K with respect to Al for Fine and Coarse fractions in Site 2



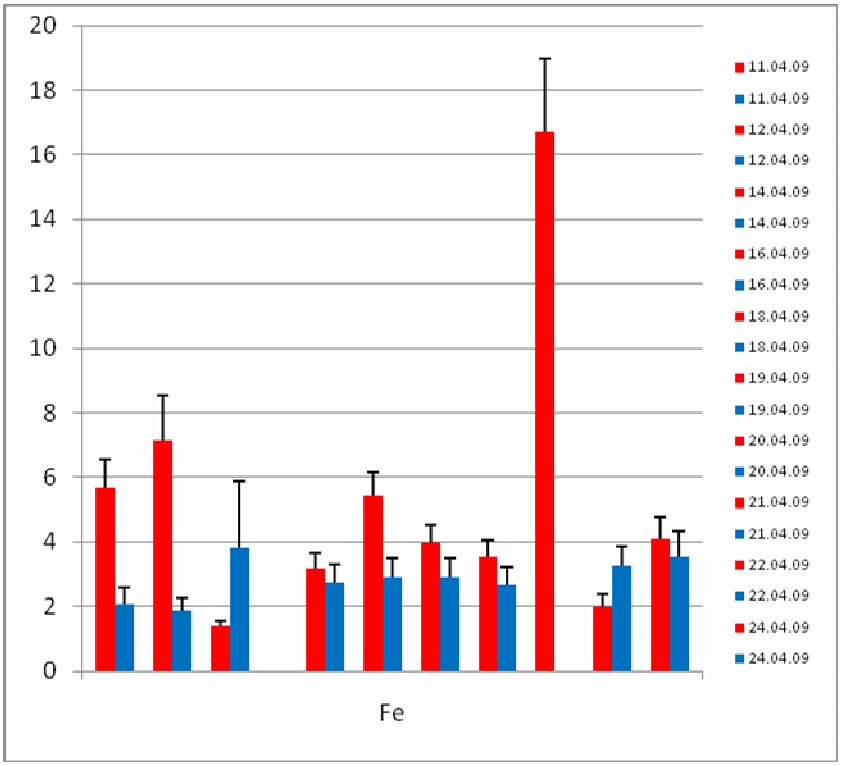
Red:Fine Particles Blue: Coarse Particles

Figure B.19 EF of Ca with respect to Al for Fine and Coarse fractions in Site 2



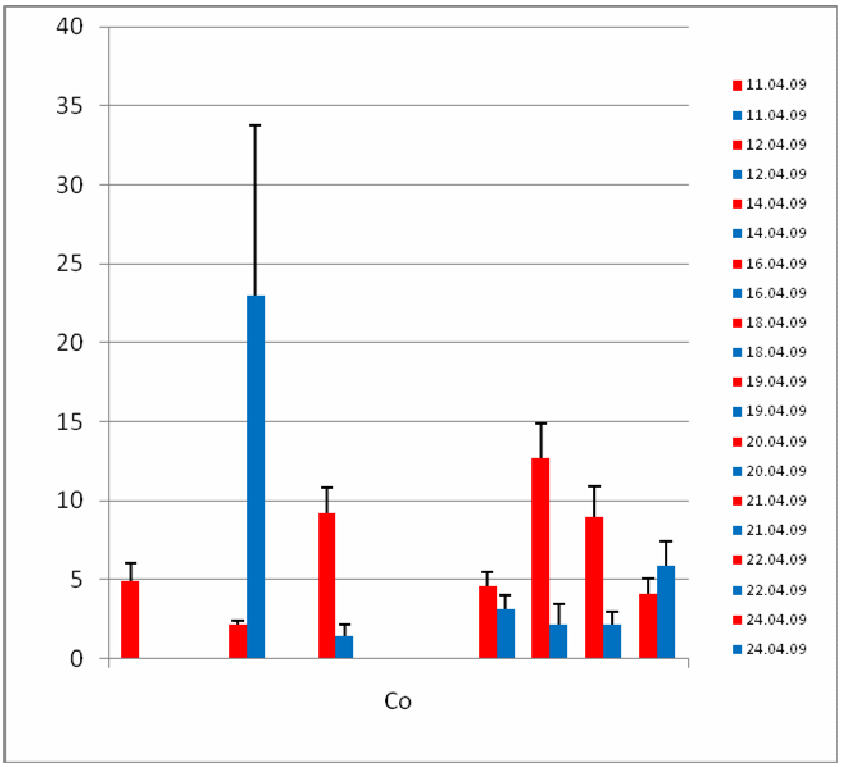
Red:Fine Particles Blue: Coarse Particles

Figure B.20 EF of Mn with respect to Al for Fine and Coarse fractions in Site 2



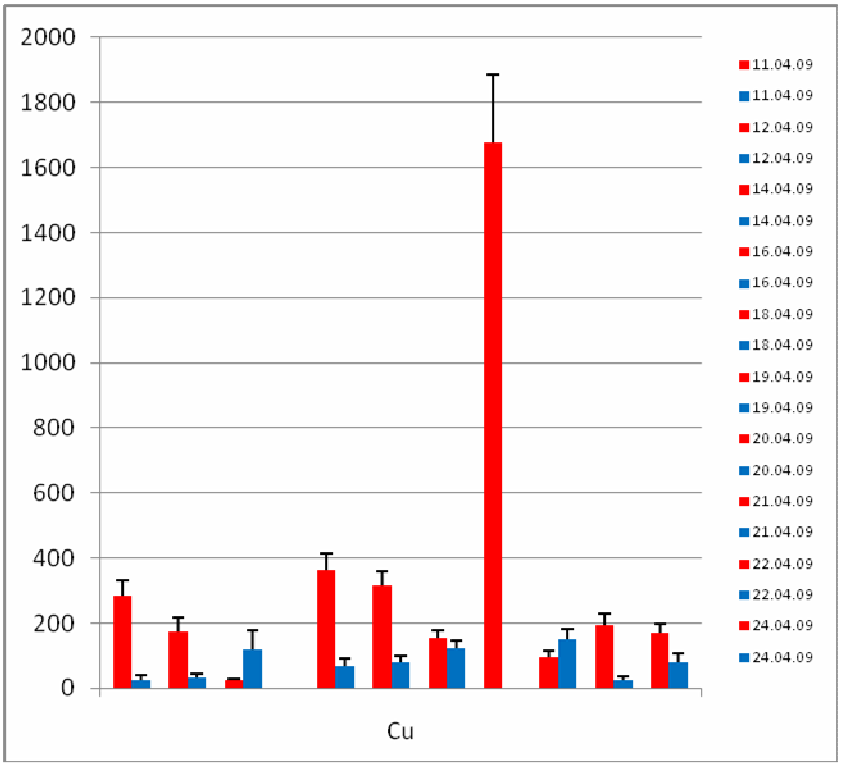
Red:Fine Particles Blue: Coarse Particles

Figure B.21 EF of Fe with respect to Al for Fine and Coarse fractions in Site 2



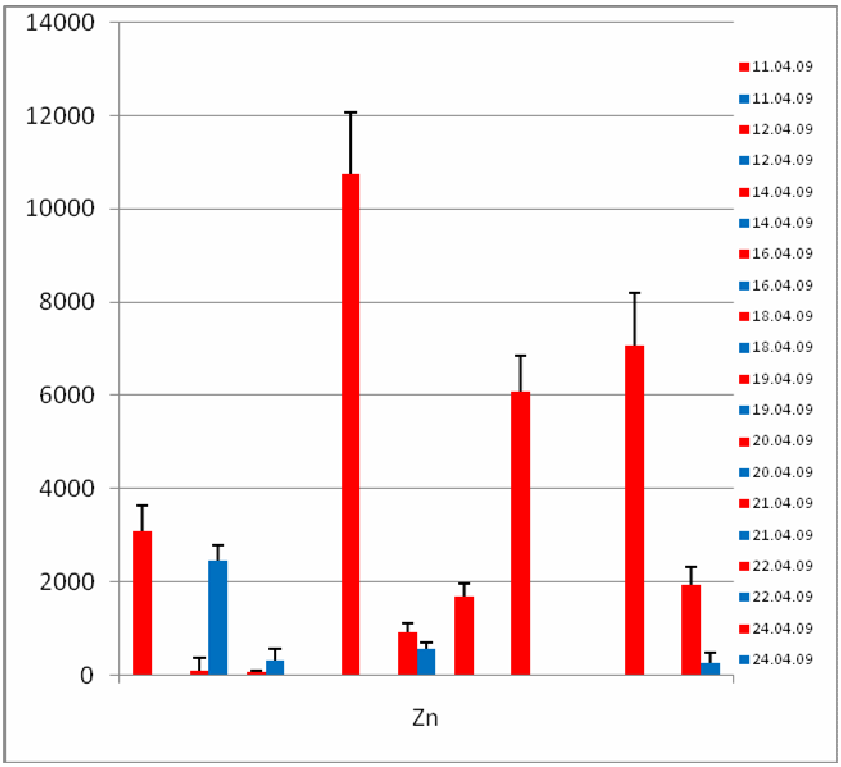
Red:Fine Particles Blue: Coarse Particles

Figure B.22 EF of Co with respect to Al for Fine and Coarse fractions in Site 2



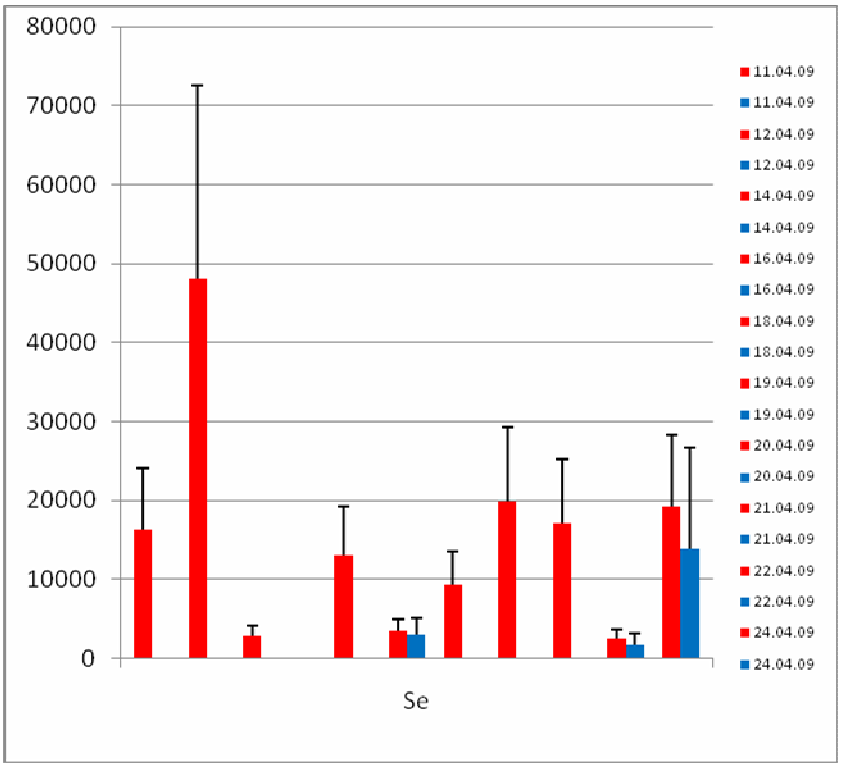
Red:Fine Particles Blue: Coarse Particles

Figure B.23 EF of Cu with respect to Al for Fine and Coarse fractions in Site 2



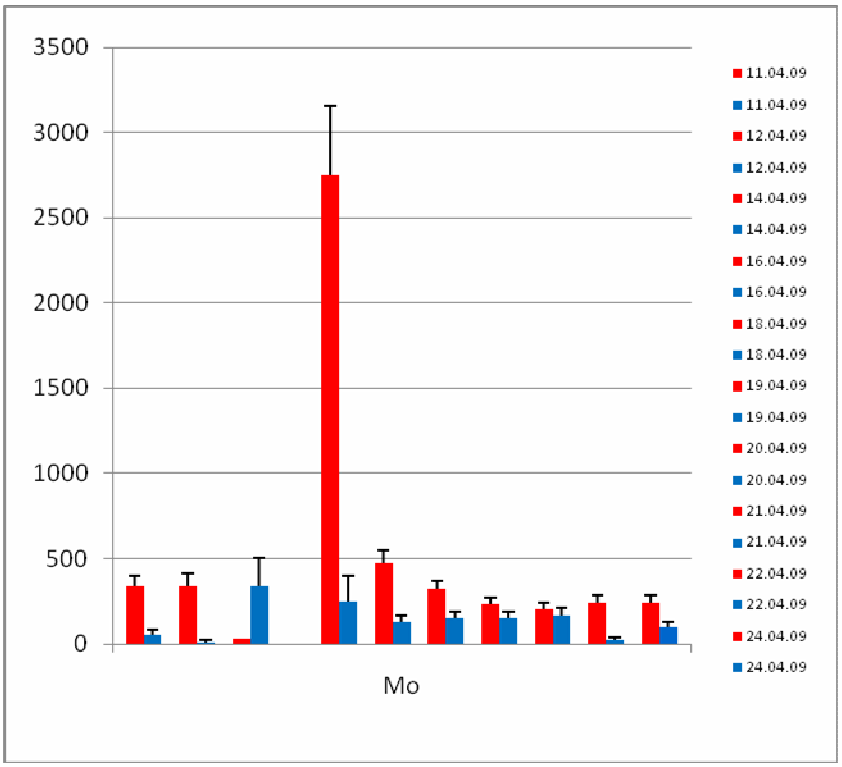
Red:Fine Particles Blue: Coarse Particles

Figure B.24 EF of Zn with respect to Al for Fine and Coarse fractions in Site 2



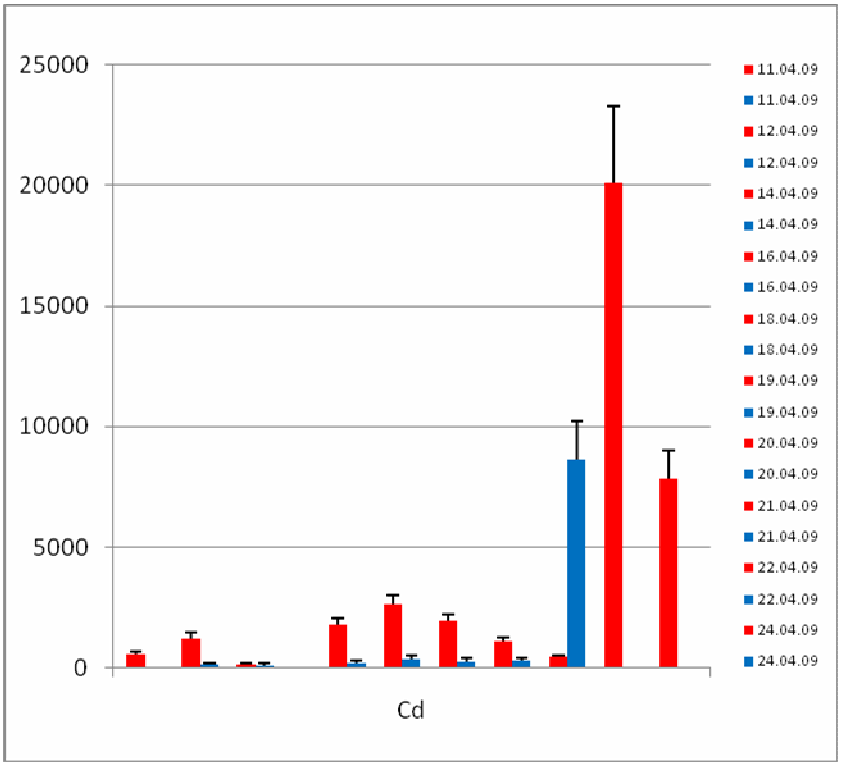
Red:Fine Particles Blue: Coarse Particles

Figure B.25 EF of Se with respect to Al for Fine and Coarse fractions in Site 2



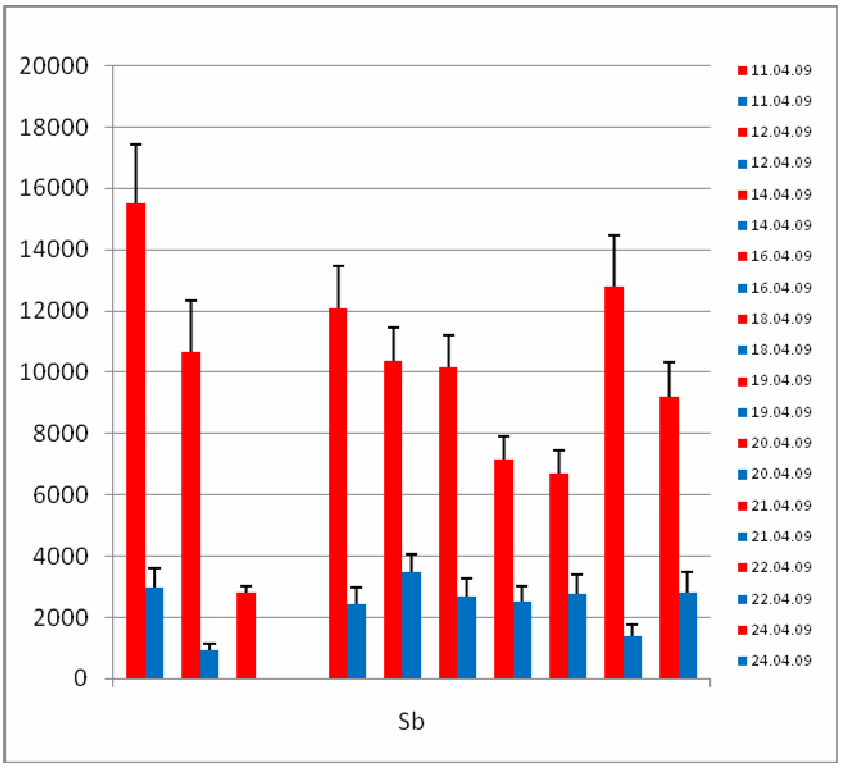
Red:Fine Particles Blue: Coarse Particles

Figure B.26 EF of Mo with respect to Al for Fine and Coarse fractions in Site 2



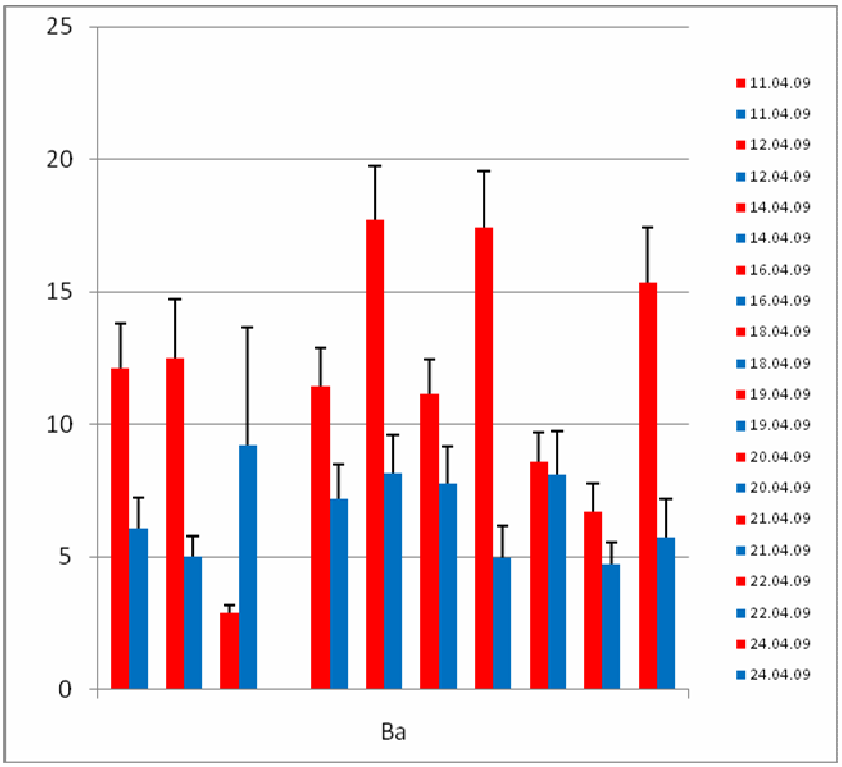
Red:Fine Particles Blue: Coarse Particles

Figure B.27 EF of Cd with respect to Al for Fine and Coarse fractions in Site 2



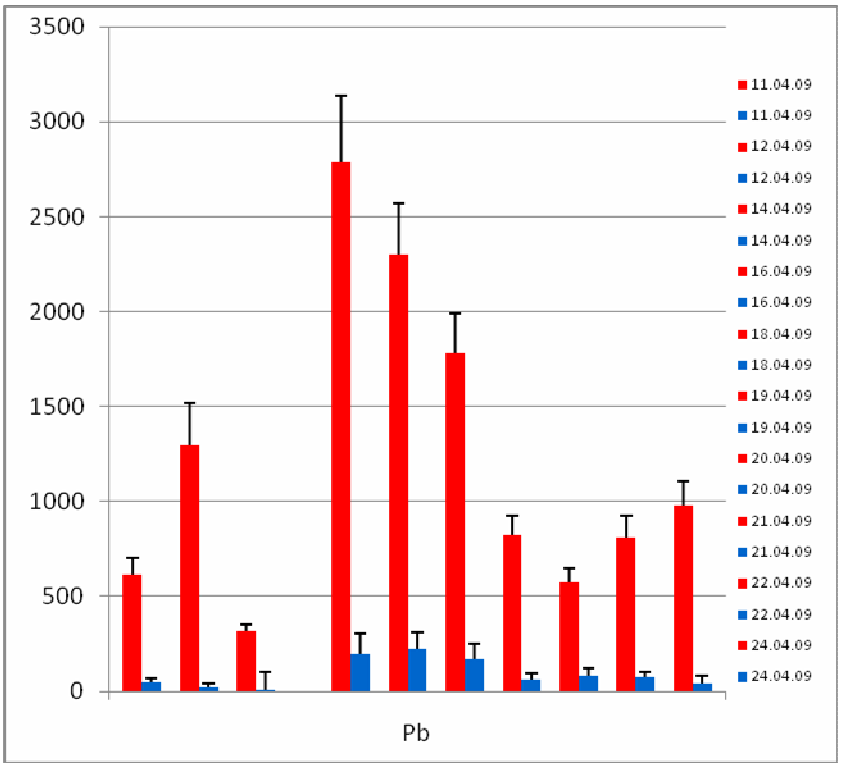
Red:Fine Particles Blue: Coarse Particles

Figure B.28 EF of Sb with respect to Al for Fine and Coarse fractions in Site 2



Red:Fine Particles Blue: Coarse Particles

Figure B.29 EF of Ba with respect to Al for Fine and Coarse fractions in Site 2



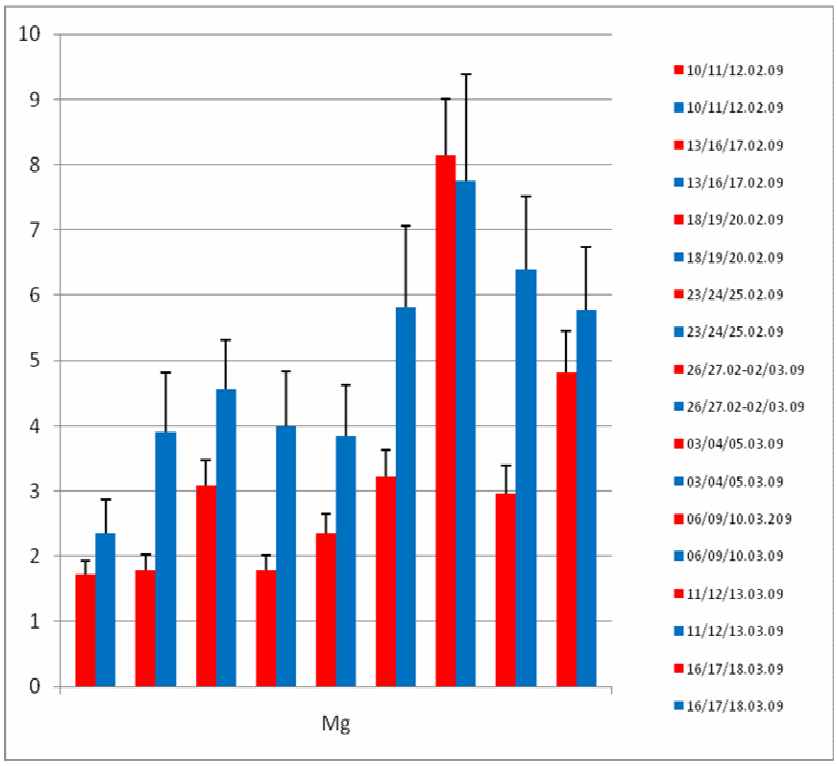
Red:Fine Particles Blue: Coarse Particles

Figure B.30 EF of Pb with respect to Al for Fine and Coarse fractions in Site 2

Table B.3 Enrichment Factors of selected elements in Coarse and Fine fractions with respect to Sodium in Site 1

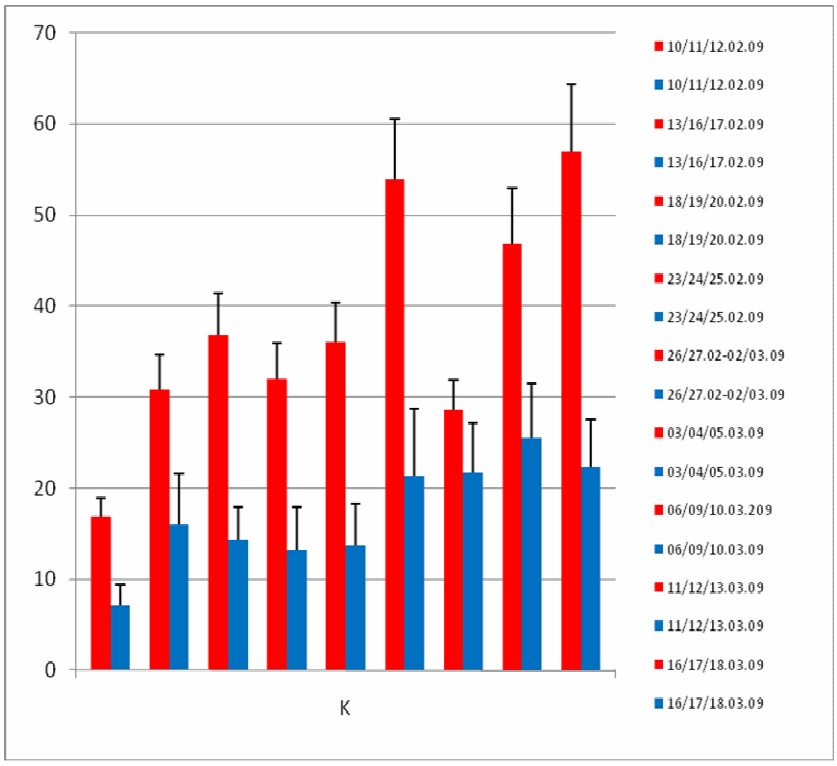
Filter No	Date	Mg			K		
S1	10/11/12.02.09	1.7	±	0.2	16.8	±	2.0
C2	10/11/12.02.09	2.4	±	0.5	7.1	±	2.4
S3	13/16/17.02.09	1.8	±	0.2	30.9	±	3.8
C4	13/16/17.02.09	3.9	±	0.9	16.0	±	5.6
S5	18/19/20.02.09	3.1	±	0.4	36.8	±	4.7
C6	18/19/20.02.09	4.6	±	0.8	14.4	±	3.5
S7	23/24/25.02.09	1.8	±	0.2	32.0	±	3.9
C8	23/24/25.02.09	4.0	±	0.8	13.2	±	4.7
S9	26/27.02-02/03.09	2.4	±	0.3	36.0	±	4.4
C10	26/27.02-02/03.09	3.8	±	0.8	13.7	±	4.6
S11	03/04/05.03.09	3.2	±	0.4	53.9	±	6.7
C12	03/04/05.03.09	5.8	±	1.3	21.3	±	7.4
S13	06/09/10.03.209	8.2	±	0.9	28.5	±	3.4
C14	06/09/10.03.09	7.8	±	1.6	21.7	±	5.4
S15	11/12/13.03.09	3.0	±	0.4	46.9	±	6.0
C16	11/12/13.03.09	6.4	±	1.1	25.6	±	6.0
S17	16/17/18.03.09	4.8	±	0.6	56.9	±	7.4
C18	16/17/18.03.09	5.8	±	1.0	22.3	±	5.2

S: fine particles C: coarse particles



Red:Fine Particles Blue: Coarse Particles

Figure B.31 EF of Mg with respect to Na for fine and coarse fractions in Site 1



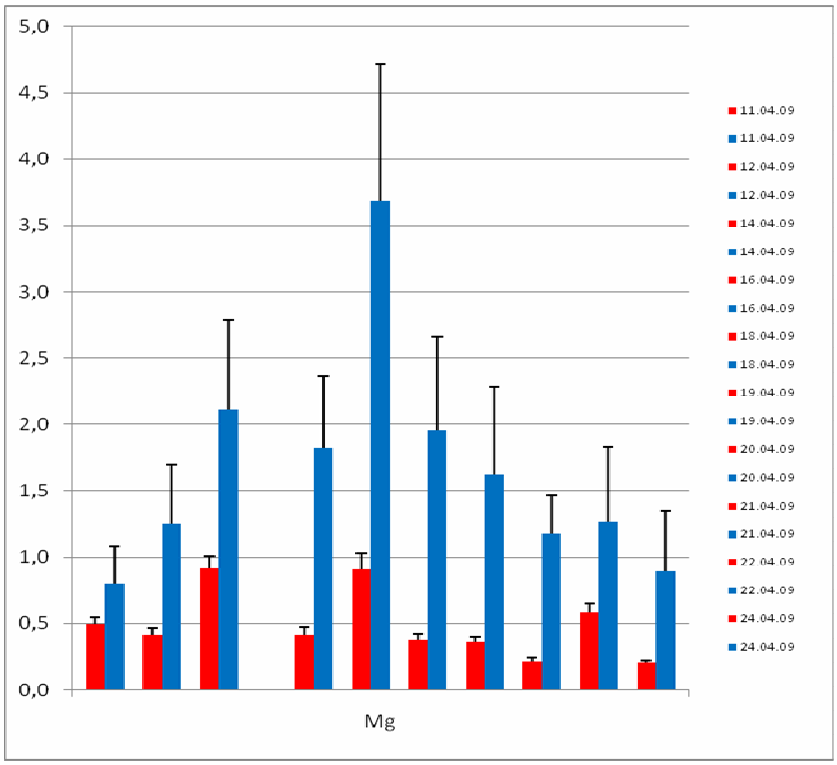
Red:Fine Particles Blue: Coarse Particles

Figure B.32 EF of K with respect to Na for fine and coarse fractions in Site 1

Table B.4 Enrichment Factors of selected elements in Coarse and Fine fractions with respect to Sodium in Site 2

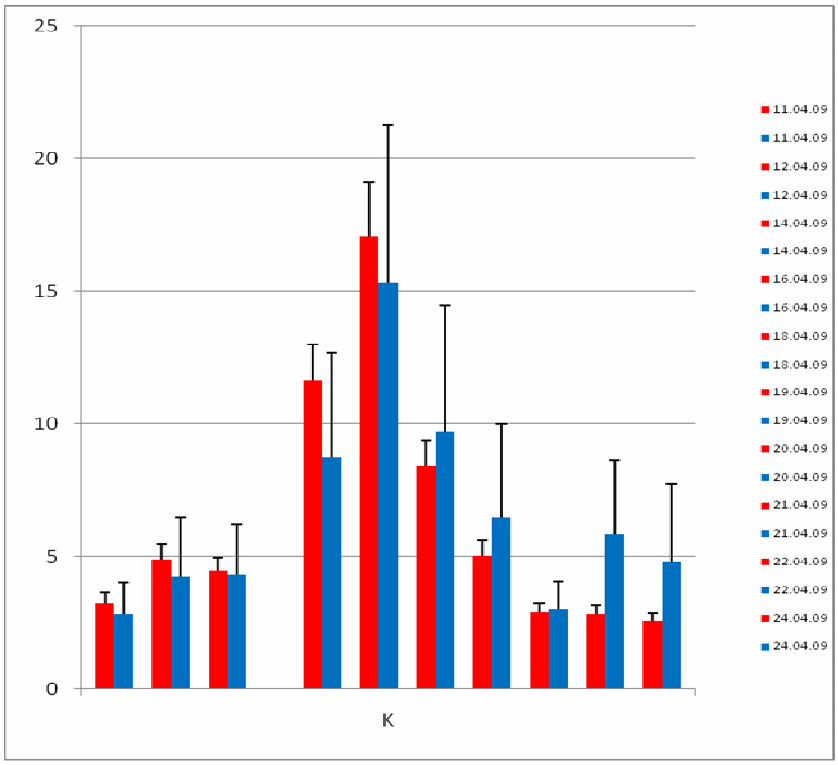
Filter No	Date	Mg			K		
S35	11.04.09	0.5	±	0.1	3.3	±	0.4
C36	11.04.09	0.8	±	0.3	2.8	±	1.2
S37	12.04.09	0.4	±	0.1	4.9	±	0.6
C38	12.04.09	1.2	±	0.4	4.2	±	2.2
S39	14.04.09	0.9	±	0.1	4.4	±	0.5
C40	14.04.09	2.1	±	0.7	4.3	±	1.9
S43	16.04.09	0.4	±	0.1	11.6	±	1.4
C44	16.04.09	1.8	±	0.5	8.8	±	3.9
S45	18.04.09	0.9	±	0.1	17.1	±	2.0
C46	18.04.09	3.7	±	1.0	15.3	±	6.0
S47	19.04.09	0.4	±	0.1	8.4	±	1.0
C48	19.04.09	2.0	±	0.7	9.7	±	4.8
S49	20.04.09	0.4	±	0.0	5.0	±	0.6
C50	20.04.09	1.6	±	0.7	6.5	±	3.5
S51	21.04.09	0.2	±	0.0	2.9	±	0.4
C52	21.04.09	1.2	±	0.3	3.0	±	1.0
S53	22.04.09	0.6	±	0.1	2.8	±	0.3
C54	22.04.09	1.3	±	0.6	5.8	±	2.8
S55	24.04.09	0.2	±	0.0	2.6	±	0.3
C56	24.04.09	0.9	±	0.5	4.8	±	2.9

S: fine particles C: coarse particles



Red:Fine Particles Blue: Coarse Particles

Figure B.33 EF of Mg with respect to Na for fine and coarse fractions in Site 2



Red:Fine Particles Blue: Coarse Particles

Figure B.34 EF of K with respect to Na for fine and coarse fractions in Site 2

APPENDIX C

COARSE TO FINE ENRICHMENT FACTOR RATIOS

Na[Average:0.737]

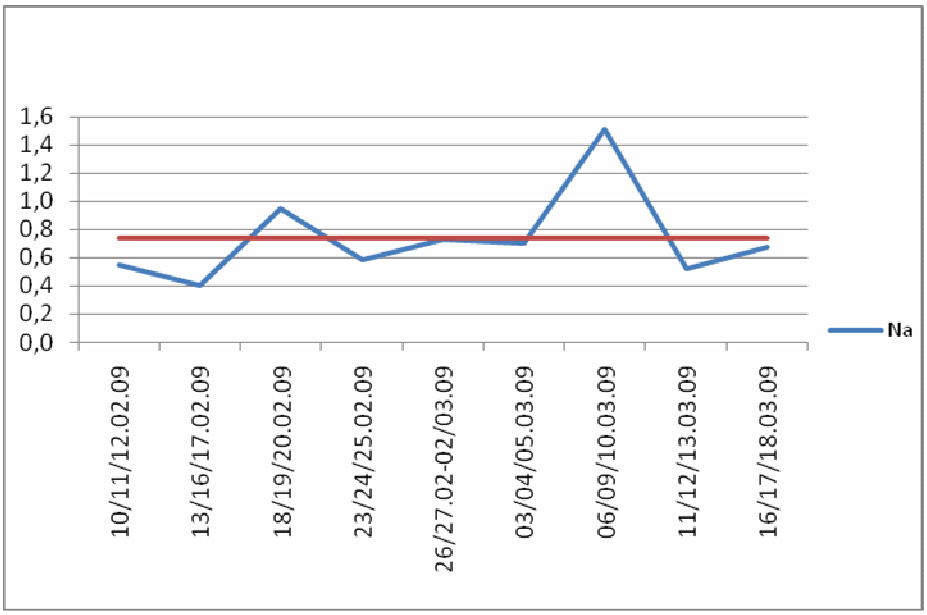


Figure C.1 Coarse to fine EF ratio of Na with respect to Al in Site 1

Mg[Average:1.132]

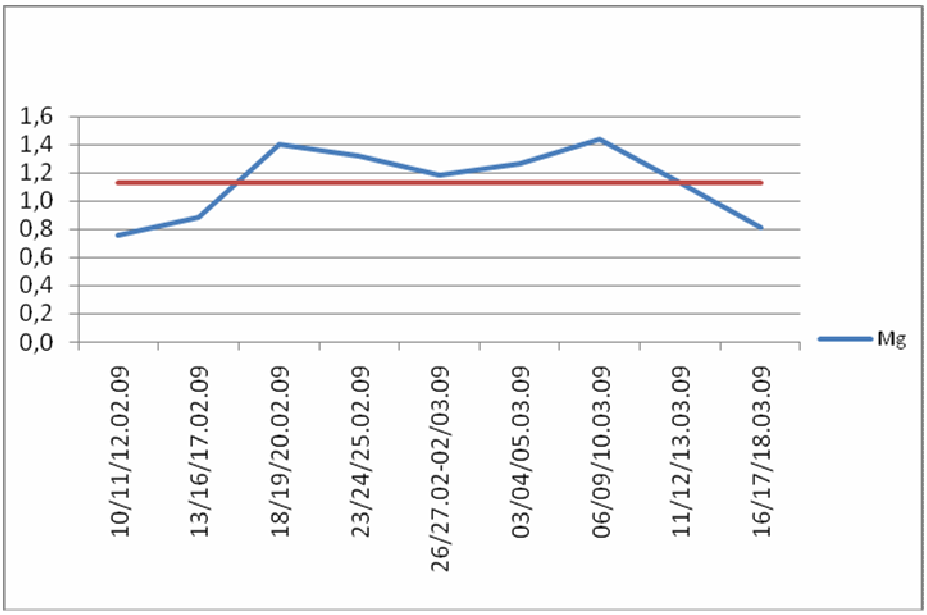


Figure C.2 Coarse to fine EF ratio of Mg with respect to Al in Site 1

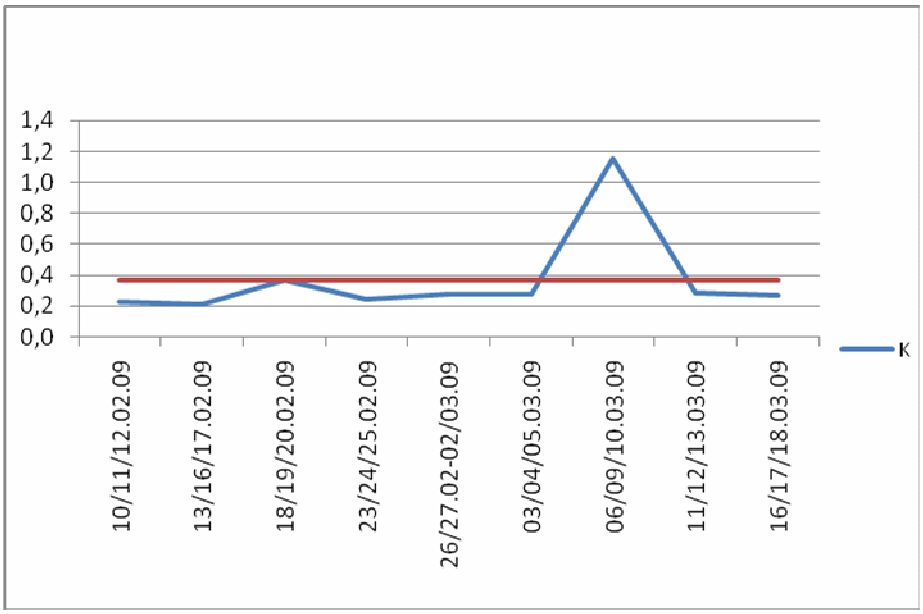


Figure C.3 Coarse to fine EF ratio of K with respect to Al in Site 1

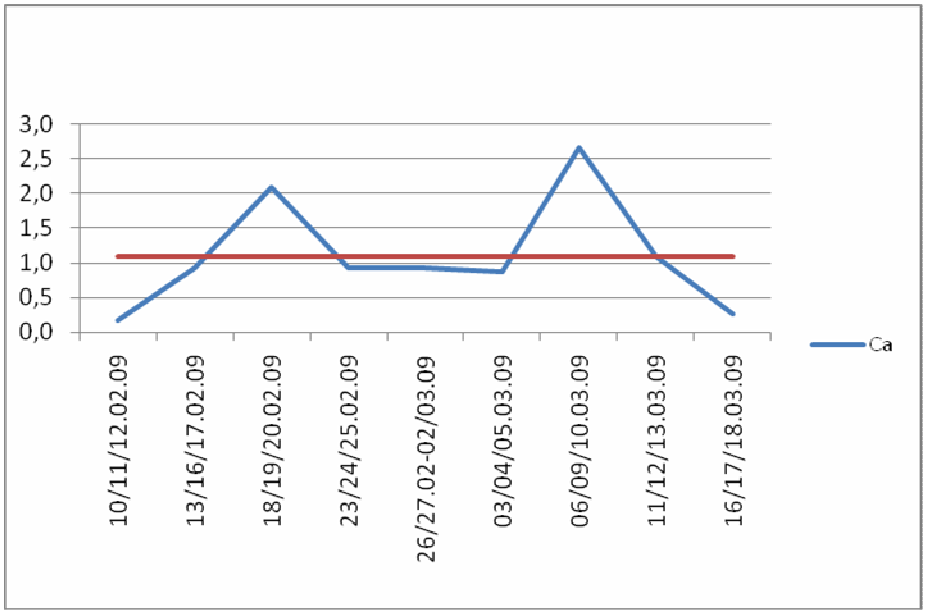


Figure C.4 Coarse to fine EF ratio of Ca with respect to Al in Site 1

Mn[Average:0.574]

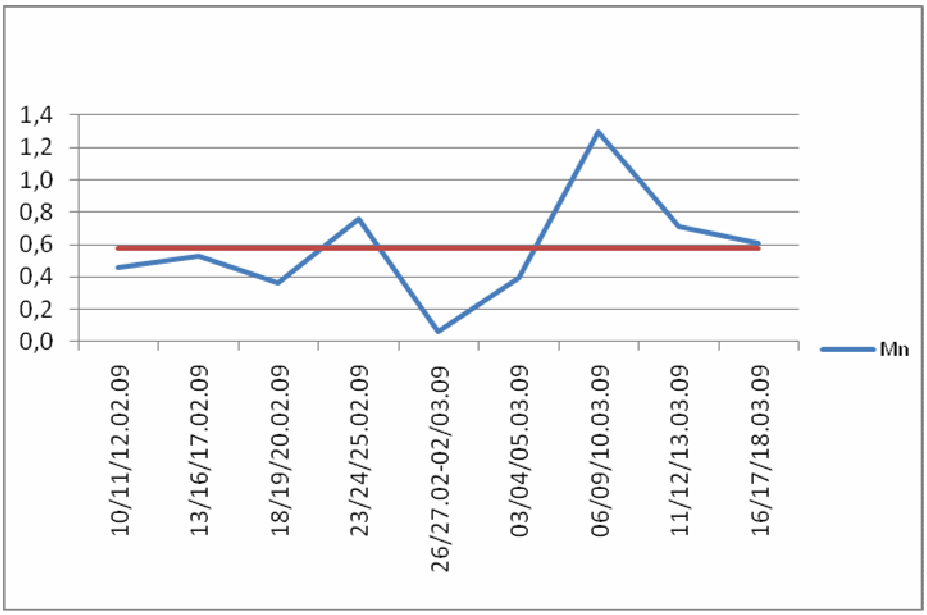


Figure C.5 Coarse to fine EF ratio of Mn with respect to Al in Site 1

Fe[Average:0.935]

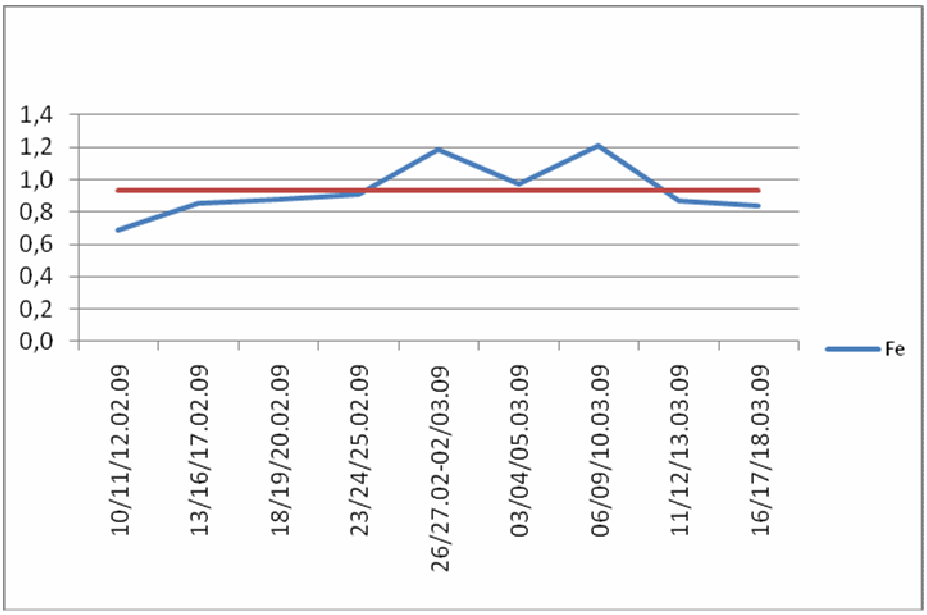


Figure C.6 Coarse to fine EF ratio of Fe with respect to Al in Site 1

Co[Average:1.24]

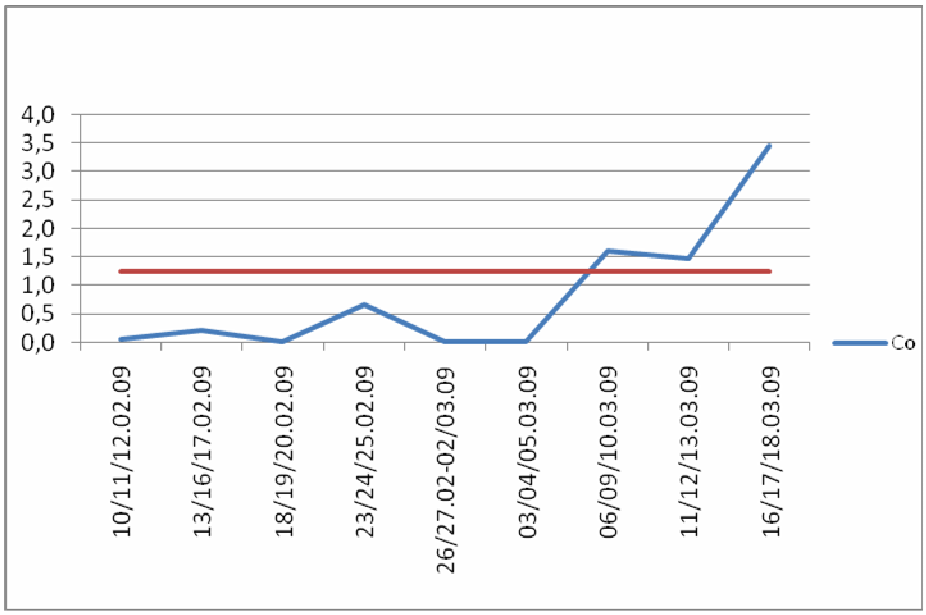


Figure C.7 Coarse to fine EF ratio of Co with respect to Al in Site 1

Cu[Average:0.631]

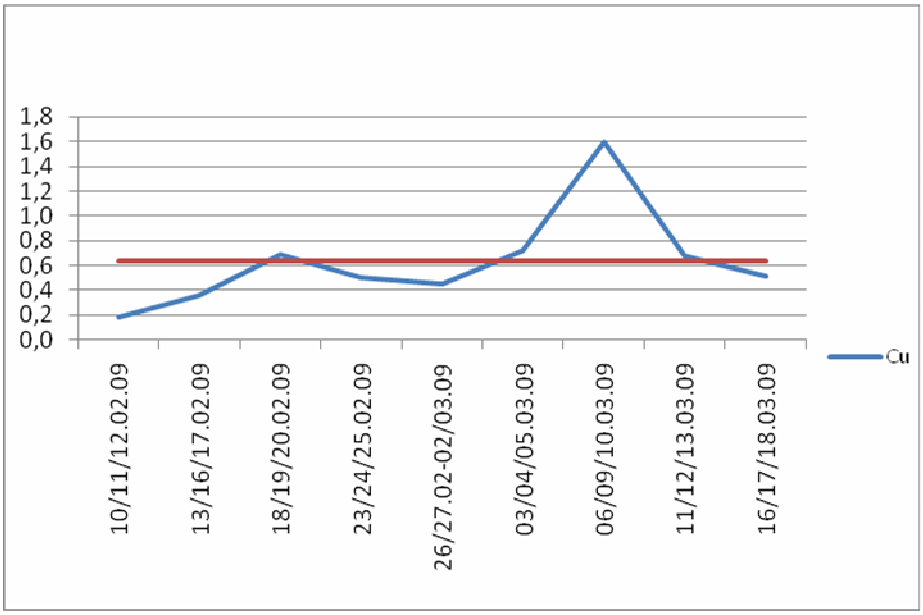


Figure C.8 Coarse to fine EF ratio of Cu with respect to Al in Site 1

Zn[Average:0.564]

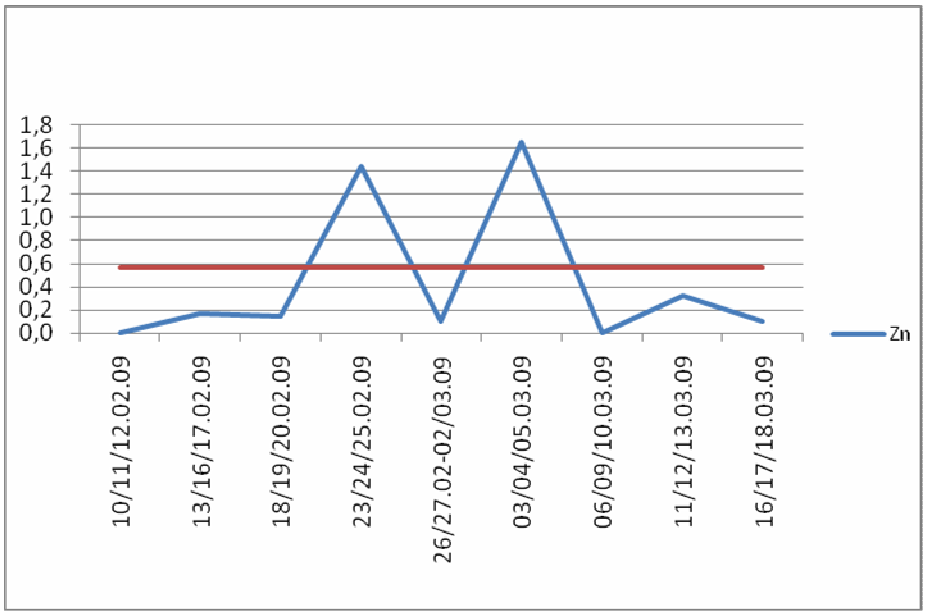


Figure C.9 Coarse to fine EF ratio of Zn with respect to Al in Site 1

Se[Average:0.519]

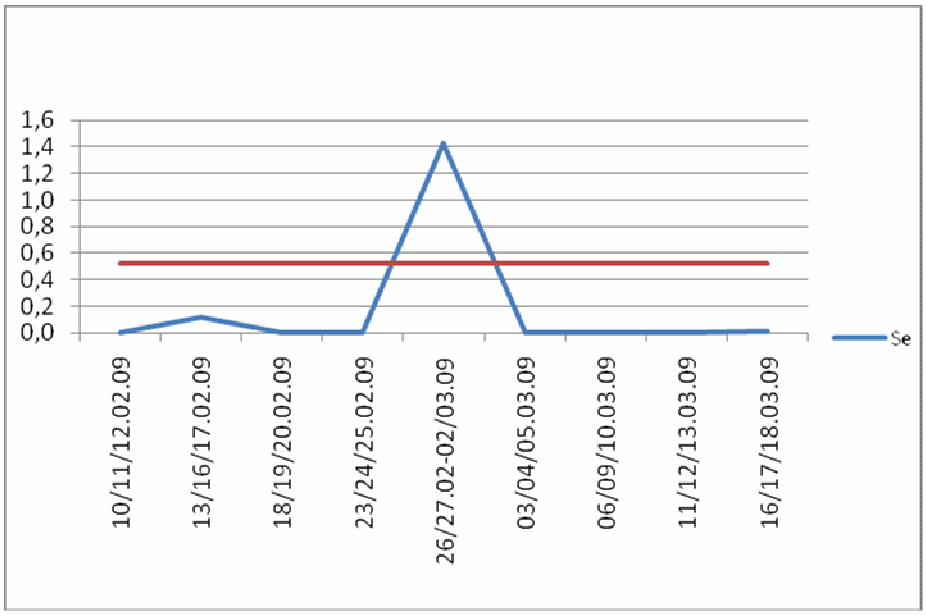


Figure C.10 Coarse to fine EF ratio of Se with respect to Al in Site 1

Mo[Average:0.682]

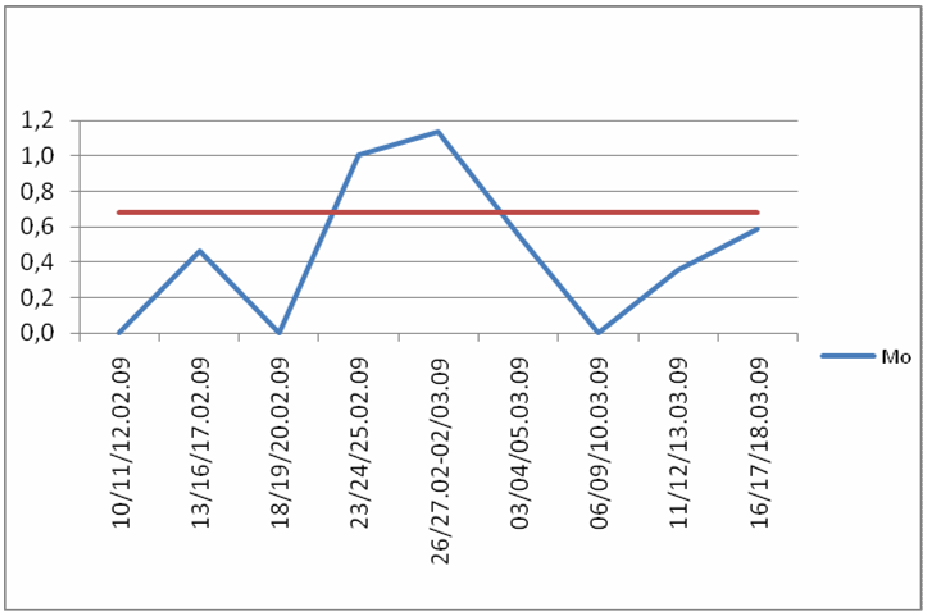


Figure C.11 Coarse to fine EF ratio of Mo with respect to Al in Site 1

Cd[Average:0.138]

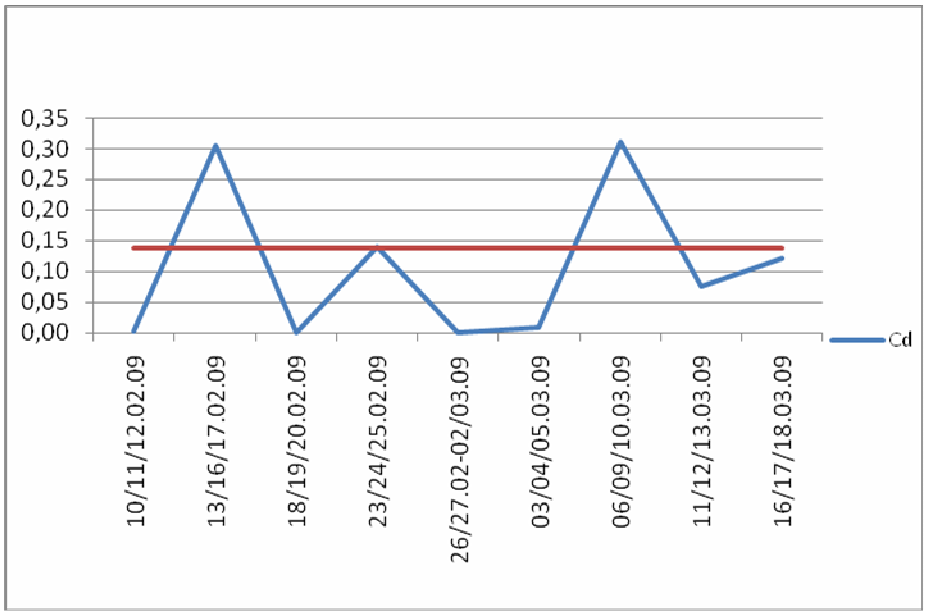


Figure C.12 Coarse to fine EF ratio of Cd with respect to Al in Site 1

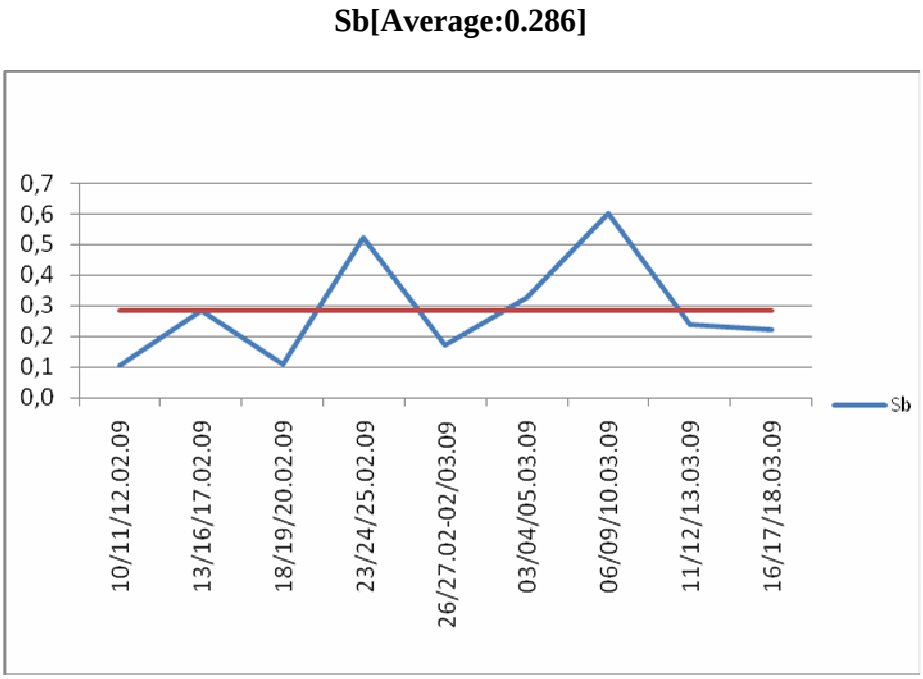


Figure C.13 Coarse to fine EF ratio of Sb with respect to Al in Site 1

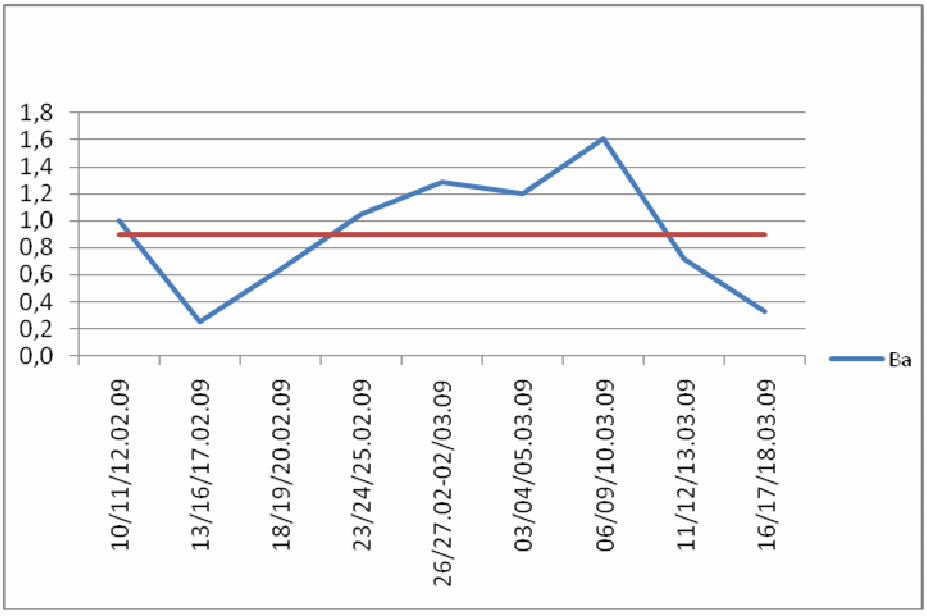


Figure C.14 Coarse to fine EF ratio of Ba with respect to Al in Site 1

Pb[Average:0.136]

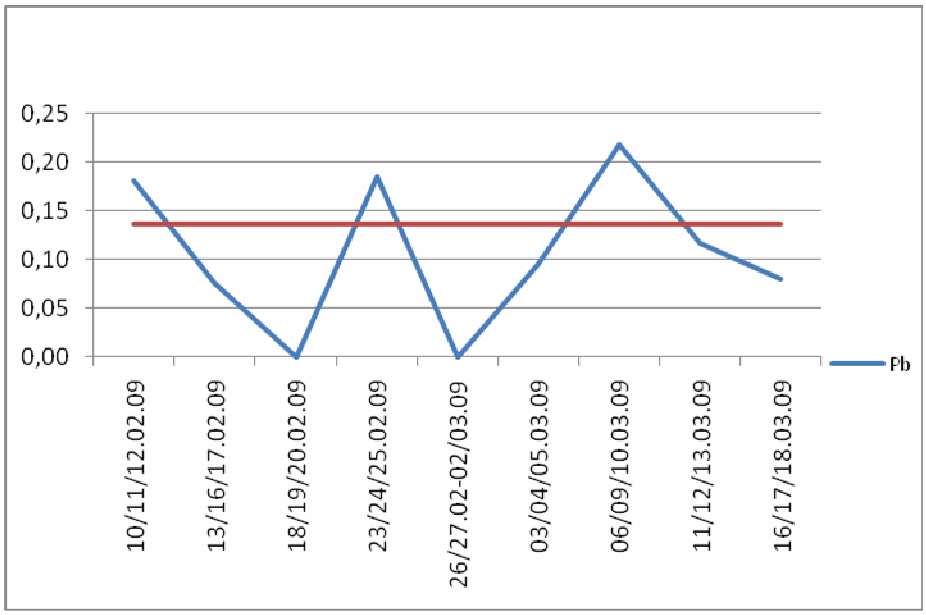


Figure C.15 Coarse to fine EF ratio of Pb with respect to Al in Site 1

Na[Average:0.416]

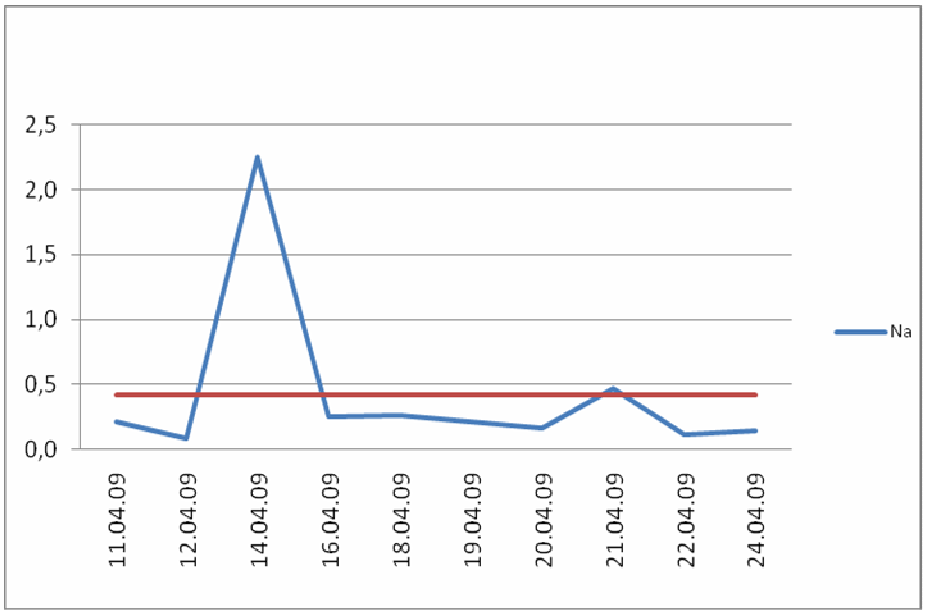


Figure C.16 Coarse to fine EF ratio of Na with respect to Al in Site 2

Mg[Average:1.321]

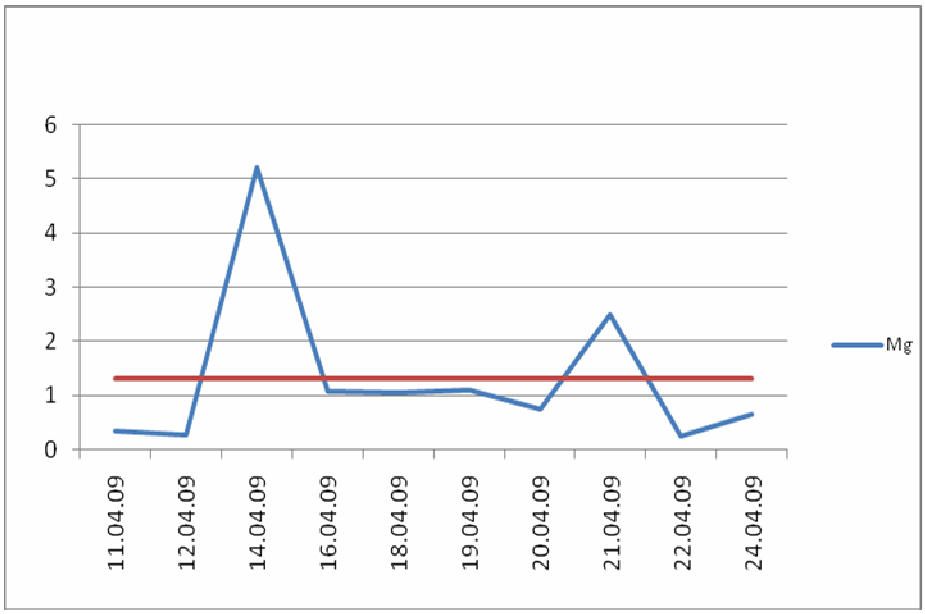


Figure C.17 Coarse to fine EF ratio of Mg with respect to Al in Site 2

K[Average:0.433]

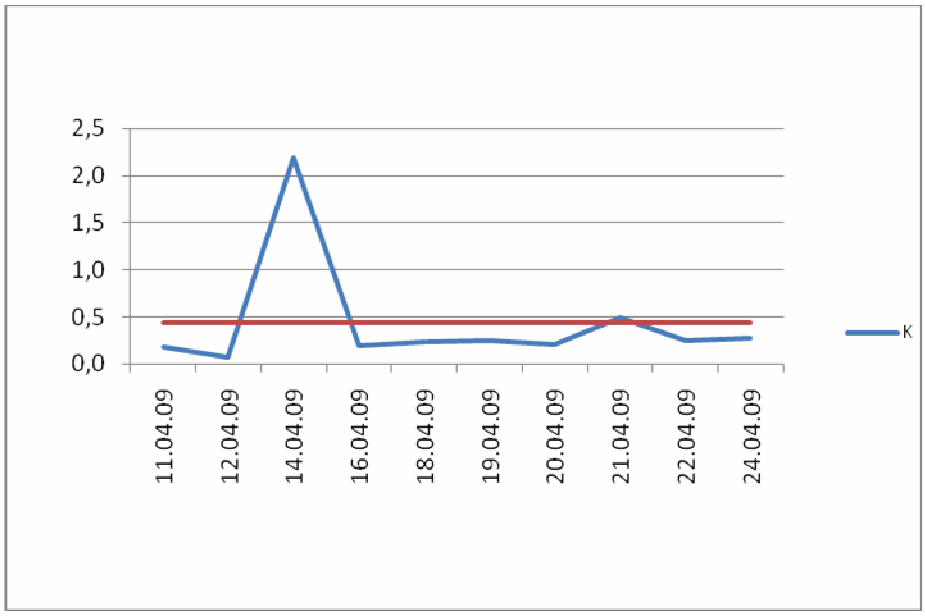


Figure C.18 Coarse to fine EF ratio of K with respect to Al in Site 2

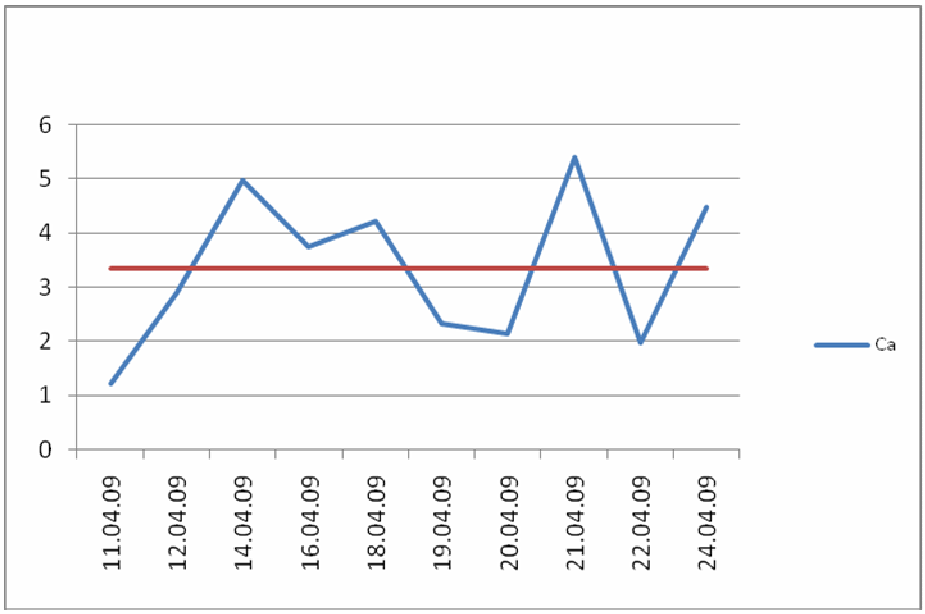


Figure C.19 Coarse to fine EF ratio of Ca with respect to Al in Site 2

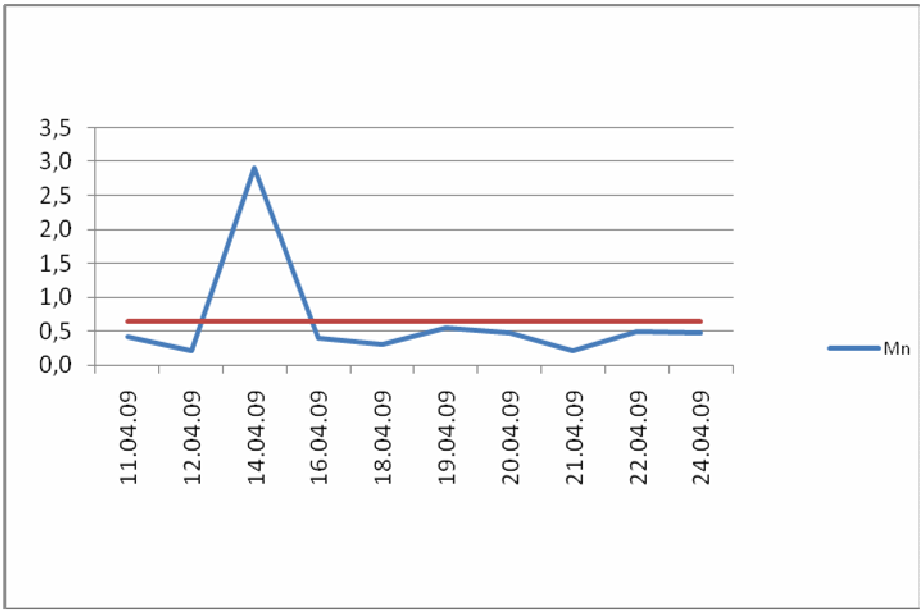


Figure C.20 Coarse to fine EF ratio of Mn with respect to Al in Site 2

Fe[Average:0.971]

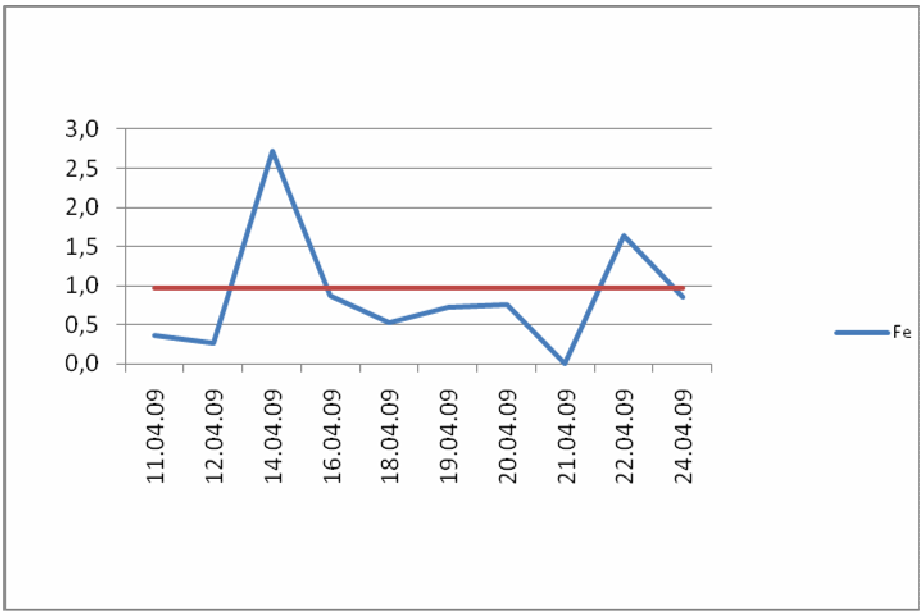


Figure C.21 Coarse to fine EF ratio of Fe with respect to Al in Site 2

Co[Average:2.256]

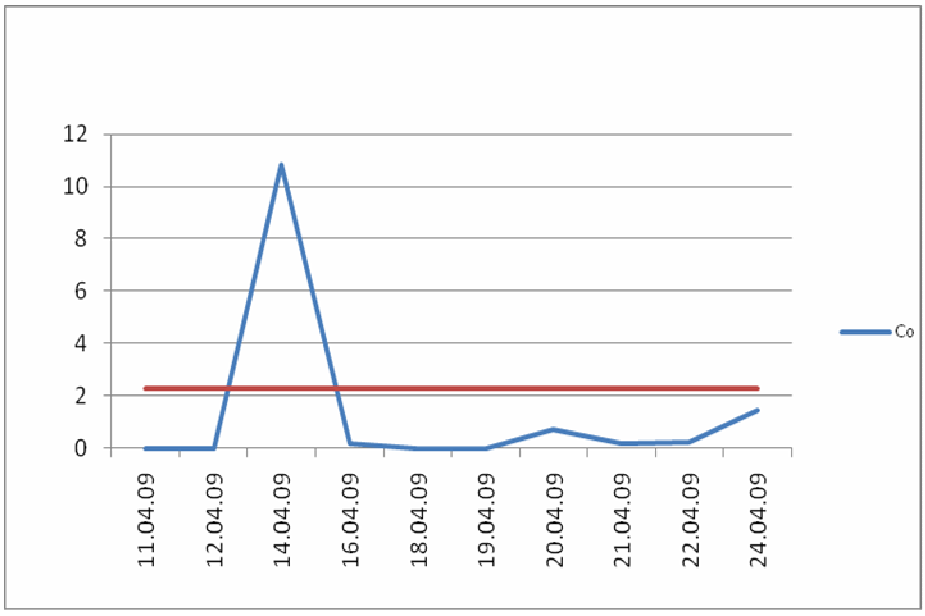


Figure C.22 Coarse to fine EF ratio of Co with respect to Al in Site 2

Cu[Average:0.942]

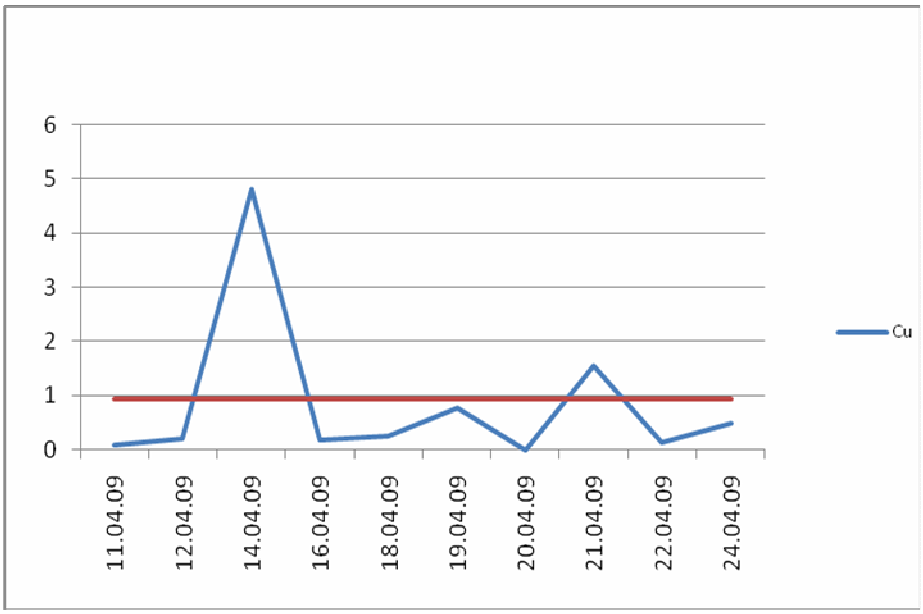


Figure C.23 Coarse to fine EF ratio of Cu with respect to Al in Site 2

Zn[Average:8.008]

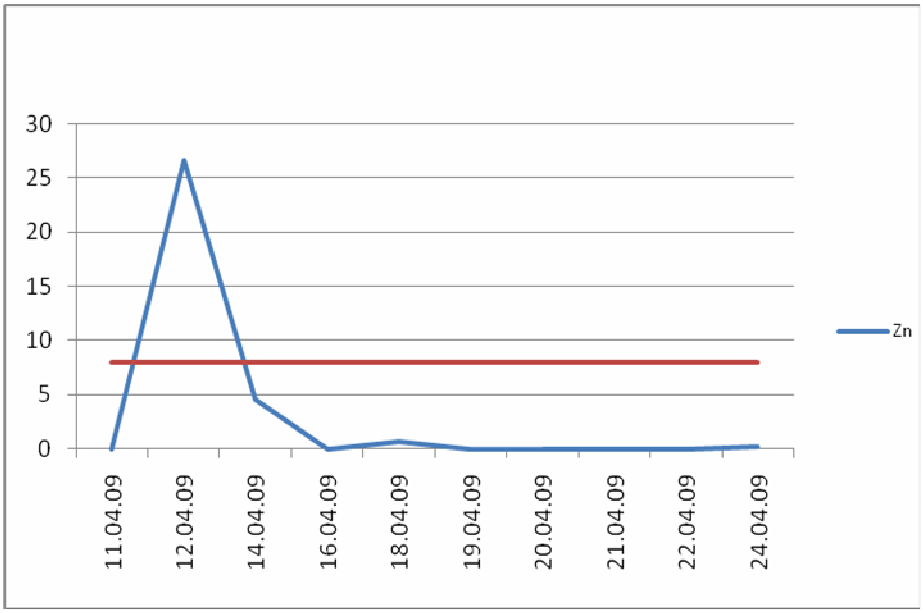


Figure C.24 Coarse to fine EF ratio of Zn with respect to Al in Site 2

Se[Average:0.776]

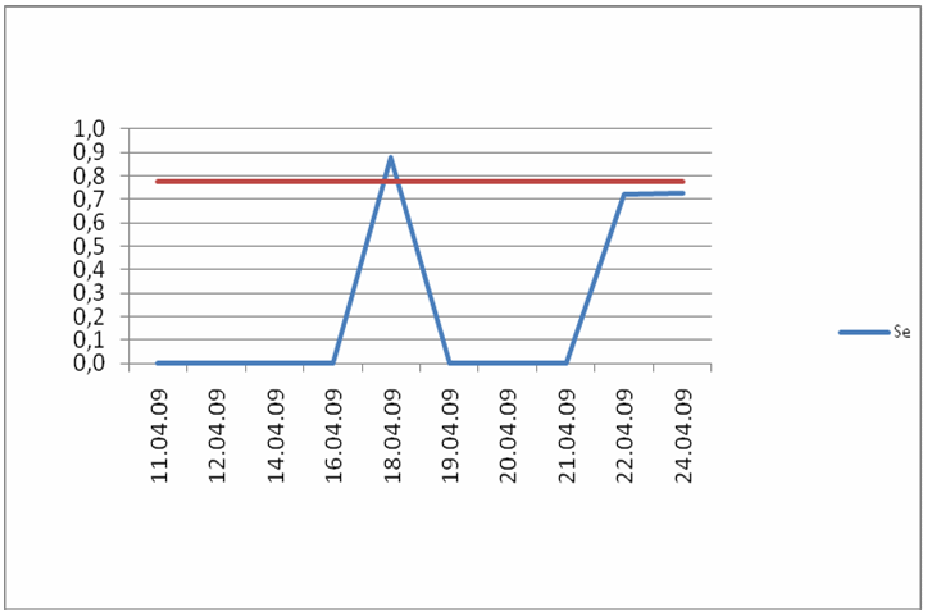


Figure C.25 Coarse to fine EF ratio of Se with respect to Al in Site 2

Mo[Average:1.5]

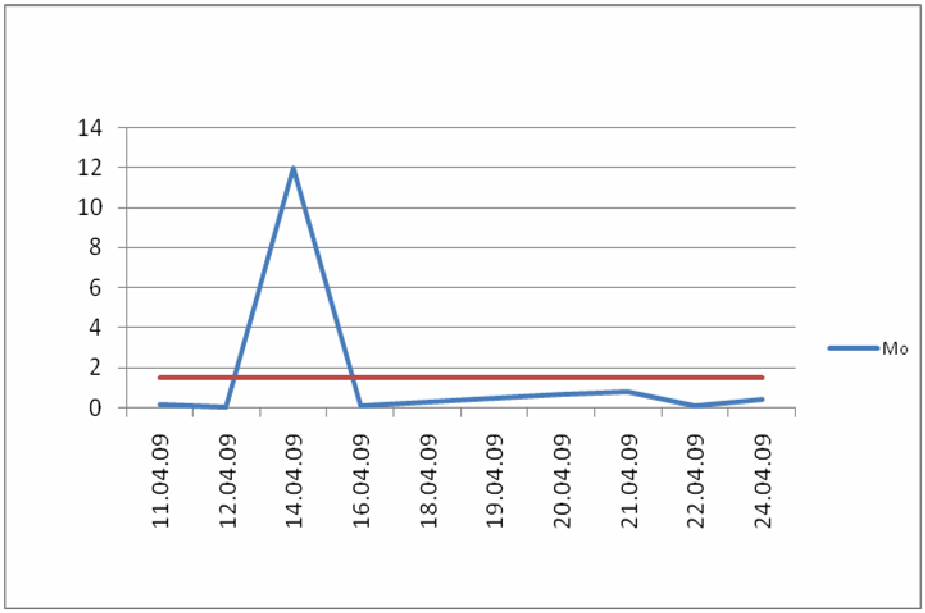


Figure C.26 Coarse to fine EF ratio of Mo with respect to Al in Site 2

Cd[Average:2.624]

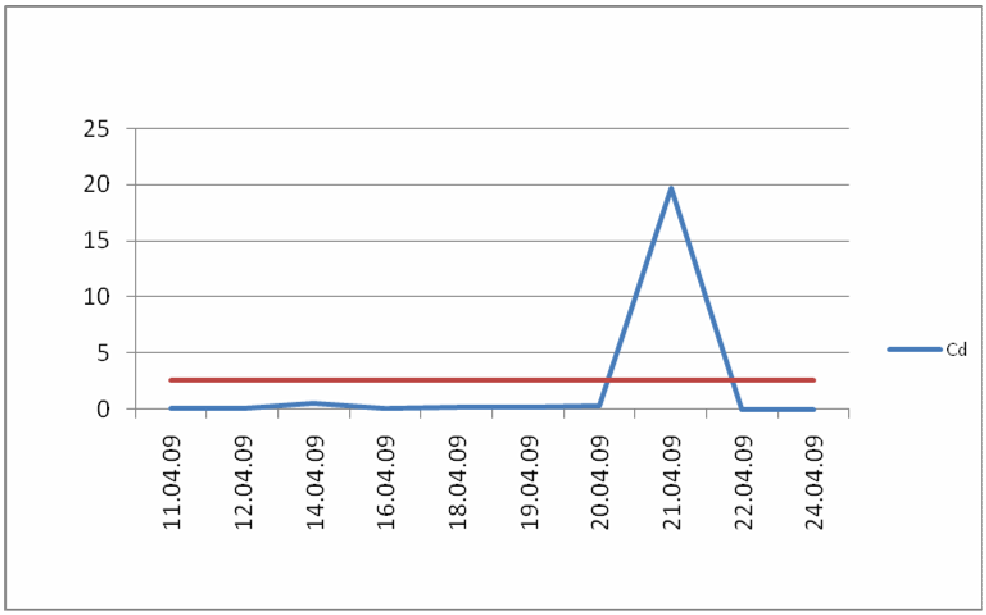


Figure C.27 Coarse to fine EF ratio of Cd with respect to Al in Site 2

Sb[Average:0.251]

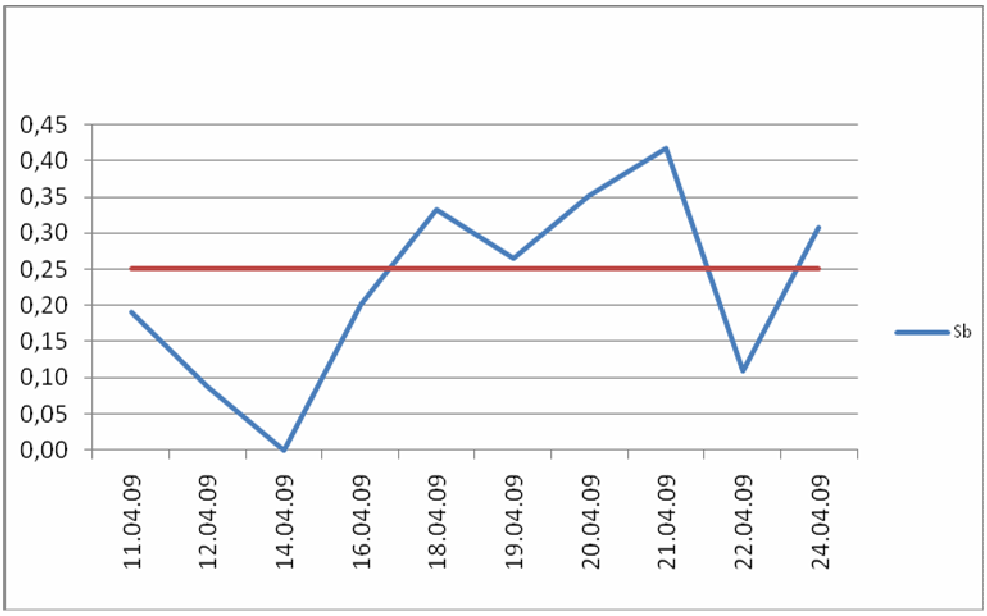


Figure C.28 Coarse to fine EF ratio of Sb with respect to Al in Site 2

Ba[Average:0.819]

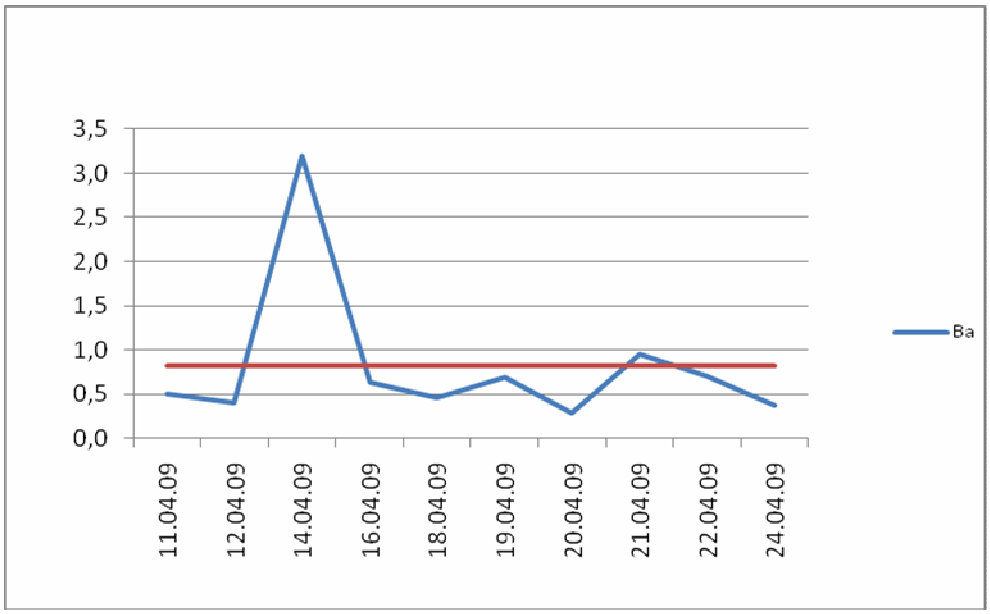


Figure C.29 Coarse to fine EF ratio of Ba with respect to Al in Site 2

Pb[Average:0.18]

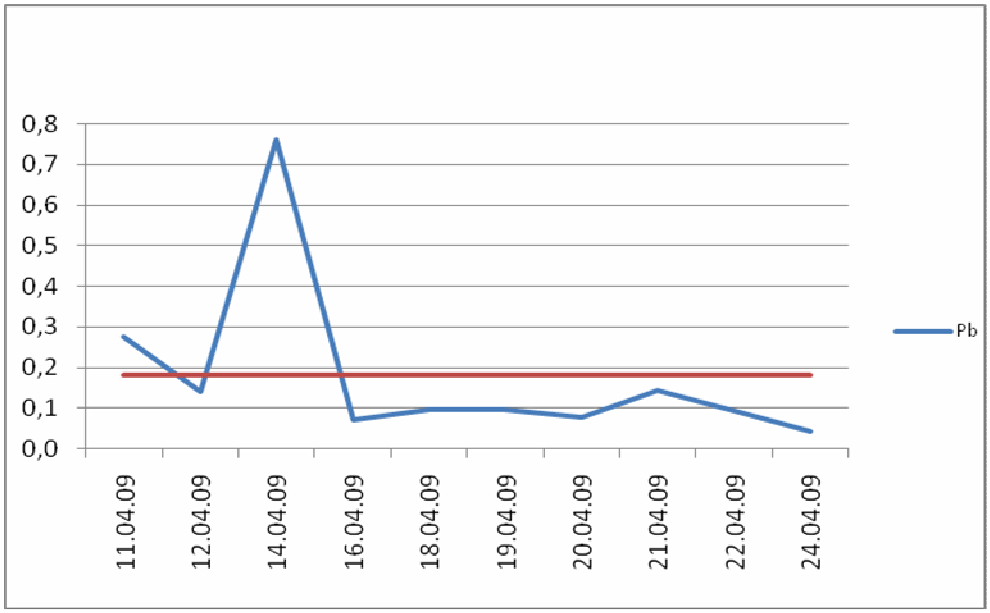


Figure C.30 Coarse to fine EF ratio of Pb with respect to Al in Site 2

Mg[Average:1.669]

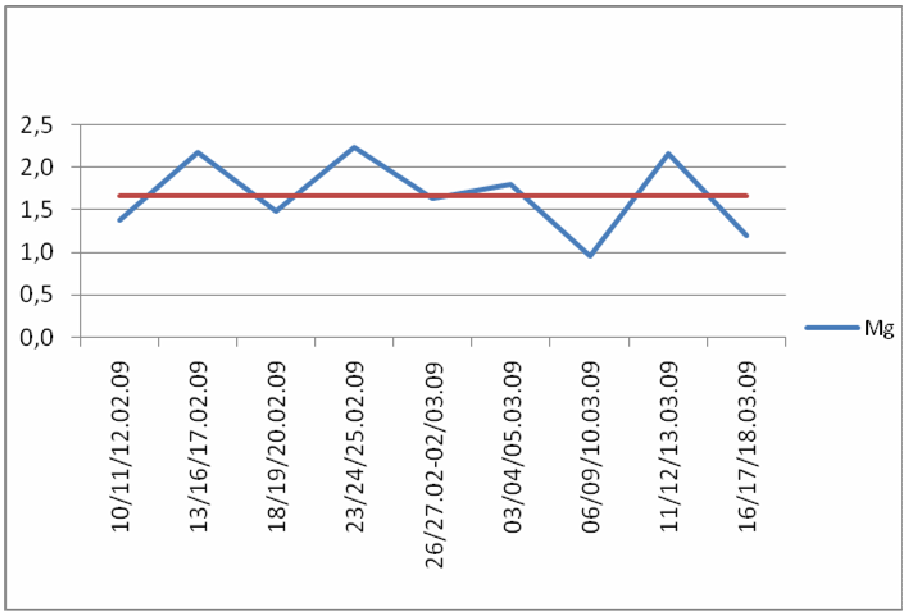


Figure C.31 Coarse to fine EF ratio of Mg with respect to Na in Site 1

K[Average:0.469]

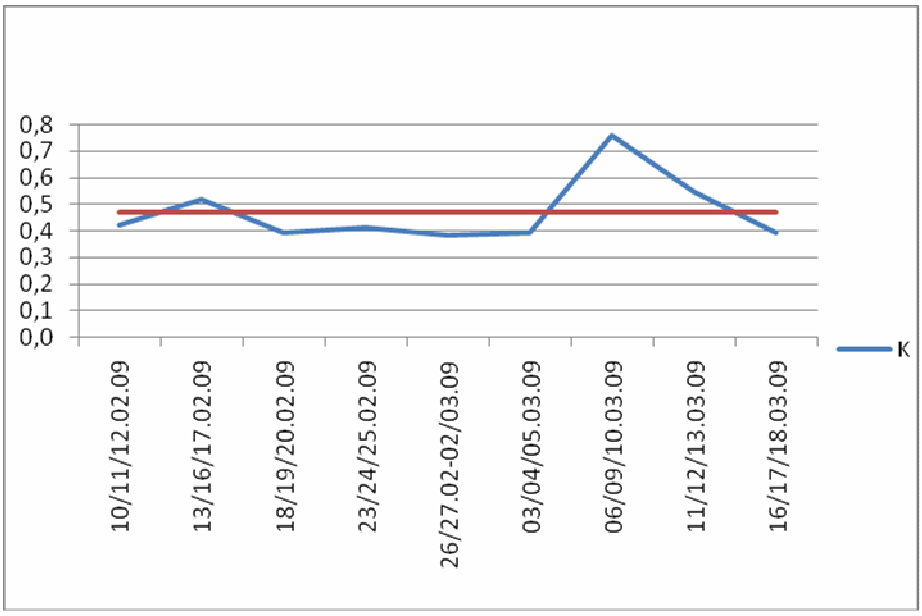


Figure C.32 Coarse to fine EF ratio of K with respect to Na in Site 1

Mg[Average:3.718]

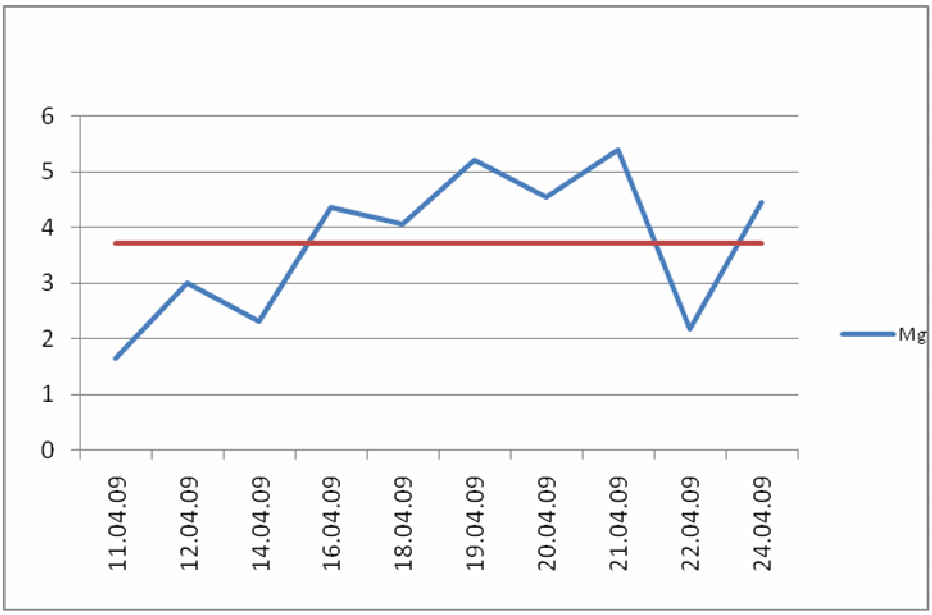


Figure C.33 Coarse to fine EF ratio of Mg with respect to Na in Site 2

K[Average:1.18]

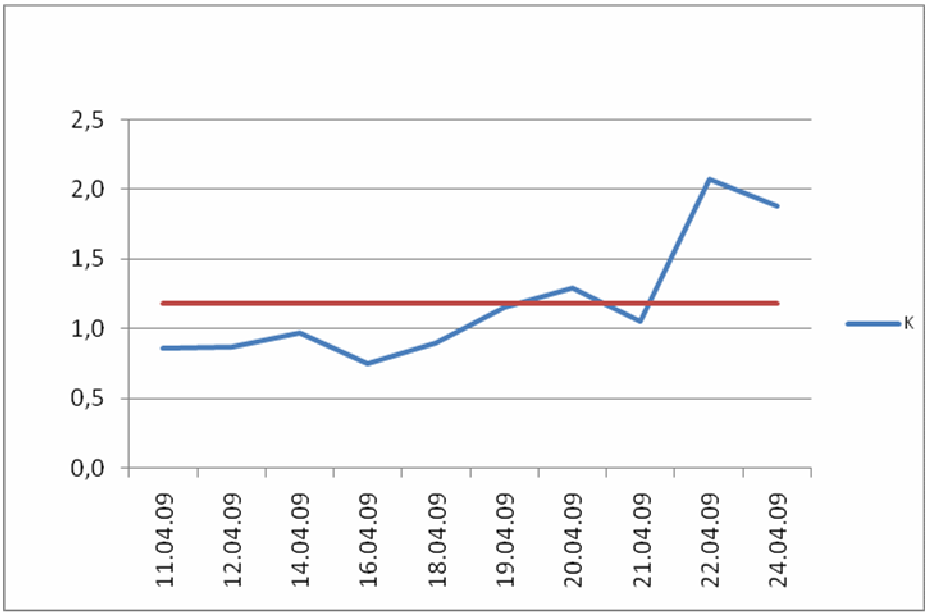


Figure C.34 Coarse to fine EF ratio of K with respect to Na in Site 2

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