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Concentrations of elements in blood and feathers of tawny owls *(Strix aluco)* from Central Norway

Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Natural Sciences
Department of Biology

Master's thesis in Environmental Toxicology and Chemistry
Supervisor: Veerle Jaspers Jan E. Østnes Tomasz M. Ciesielski
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Abstract

Human activities have disturbed the natural biochemical balance and the geochemical cycles of many elements, resulting in metals and other elements being more concentrated and available for exposure and uptake in biota. Because there is little data available on exposure to toxic elements in terrestrial ecosystems in Central Norway, the aim of the present study was to investigate the presence and concentrations of a wide range of essential and non-essential elements in an avian top predator, the tawny owl (*Strix aluco*). Since tawny owls remain within a restricted territory throughout the year, each individual is expected to reflect the elemental concentrations in their territory and thus can be used to detect possible elemental pollution in its local environment.

The concentrations of elements in tawny owls were analyzed using blood and feather samples from adult females (n=28 and n=72, respectively) and their nestlings (n=35 and n=61, respectively). Samples were collected during three field seasons (2016-2018) from 45 different territories. Feathers were washed in a five-step washing procedure prior to the element analysis to remove external contamination. Both blood and feather samples were analyzed for elemental concentrations in an ICP-MS. In addition, GIS-analysis was used to quantify the proportion of different landscape parameters within each territory.

Most elements were found at significantly higher concentrations in feathers compared with blood, and two of the elements revealed positive correlations between blood and feathers in adults (Hg and Mg) and several elements in nestlings (B, Hg, La, Mo, Rb, Se, Sr and U). This indicates a transport of these elements into growing feathers proportional to the blood levels and thus feathers can be used for non-destructive biomonitoring of these elements.

In a comparison of adults and nestlings, most elements were detected at higher levels in the feathers of adults compared with the nestlings. This was expected and may be a result of the fact that concentrations increase with the age of feathers, as adults have more time to acquire and bioaccumulate contaminants. The adult feathers might also have a slightly different composition, as they are fully formed, compared to the developing feathers of the nestlings. Many elements (n=22) were positively correlated between adult and nestling feathers, most of them probably due to external deposition. Two elements were positively correlated between adult and nestling blood (Cd and Cs), three elements were positively correlated between adult feathers and nestling blood (Ba, Hg and Se) and three elements were positively correlated

between adult blood and nestling feathers (As, Hg, and Se). These correlations could be due to transfer from the mother into the egg, and/or to common diet.

There were several interesting significant correlations between elements in feathers and/or blood of tawny owls and different land use within their territory, e.g. Fe and Sb were correlated with the proportion of settlements, Co and Sb with the proportion of agricultural land, Hg and Pb with the proportion freshwater lakes, and Rb and Hg with the proportion of forest.

For these elements, the area of the relevant land use significantly affected the elemental concentrations, and they might be useful parameters to monitor in the respective areas.

Sammendrag

Menneskelig aktivitet har forstyrret den naturlige biokjemiske balansen og de geokjemiske syklusene for mange elementer. Dette har resultert i at metaller og andre grunnstoff blir mer konsentrerte og mer tilgjengelige for eksponering og opptak i miljøet. Da det foreligger lite data på mulig eksponering for giftige elementer i terrestriske økosystemer i Midt-Norge, var målet med denne studien å undersøke tilstedeværelsen og konsentrasjonen av et bredt spekter essensielle og ikke-essensielle elementer i kattugler (*Strix aluco*). Kattugler, som er topp-predatorer, er stasjonære innenfor sitt leveområde gjennom hele året, og det forventes at hvert individ reflekterer konsentrasjoner av elementer i sitt territorium. De kan dermed avdekke en mulig forurensning i det lokale økosystemet.

Fjær og blodprøver fra voksne hunner (henholdsvis n = 72 og n = 28) og deres reirunger (henholdsvis n = 61 og n = 35) ble samlet inn gjennom tre hekkesesonger (2016-2018) fra 45 territorier. Fjærprøvene ble vasket i en fem-trinns vaskeprosess før elementanalysen for å fjerne eksterne forurensninger. Både blod- og fjærprøver ble analysert i en ICP-MS for å bestemme konsentrasjoner av elementer. I tillegg ble det benyttet GIS-analyser til å beregne arealet av de ulike landskapstypene innenfor hvert territorium.

De fleste av elementene hadde betydelig høyere konsentrasjoner i fjær sammenlignet med blod, og for noen av elementene ble det påvist positive korrelasjoner mellom blod og fjær hos voksne (som Hg og Mg), og hos reirunger (som B, Hg, La, Mo, Rb , Se, Sr og U). Dette indikerer en deponering av disse elementene til fjær under fjærutviklingen. Dette indikerer en overføring av elementer som er proporsjonal med blodnivåene, og fjær kan dermed benyttes i en ikke-invasiv biomonitoring av nettopp disse elementene.

I en sammenligning mellom voksne hunner og reirunger ble de fleste elementer påvist med høyere nivå i fjær fra voksne sammenlignet med ungene. Dette var forventet og kan være et resultat av at konsentrasjoner akkumuleres med økende alder på fjær, da voksne har lengre tid til å bioakkumulere forurensninger. Fjær fra de voksne hunnene kan også ha en annen sammensetning ettersom de er ferdig utviklet, til forskjell fra reirungenes fjær som er under utvikling. Mange elementer (n=22) korrelerte mellom fjær fra voksne og fjær fra reirunger, og de fleste av korrelasjonene skyldes sannsynligvis ekstern deponering. Det var positiv korrelasjon mellom konsentrasjonen av to av elementene i blod fra voksne og blod fra reirunger (Cd og Cs), tre elementer korrelerte positivt mellom fjær fra voksne og blod fra reirunger (Ba, Hg og Se) og tre elementer korrelerte positivt mellom blod fra voksne og fjær fra reirunger (As,

Hg og Se). Disse korrelasjonene kan skyldes overføring fra mor til egg og/eller at de har samme diett.

Det var flere interessante signifikante korrelasjoner for elementer i fjær og/eller blod fra kattugler og landskapstyper innenfor deres territorier. For eksempel korrelerte Fe og Sb med arealet av bosetninger, Co og Sb med arealet av jordbruk, Hg og Pb med arealet av ferskvann, og Rb og Hg med arealet av skog.

Elementer som ble analysert i dette forsøket, og hvor konsentrasjonene ble signifikant positivt påvirket av proporsjonen av den aktuelle arealtypen, kan være nyttige parametere å bruke i arbeidet med å overvåke de respektive områdene.

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Table of contents

Abbreviations

Ag	Silver
Al	Aluminum
As	Arsenic
Au	Gold
B	Boron
Ba	Barium
Bi	Bismuth
Ca	Calcium
Cd	Cadmium
Ce	Cerium
Co	Cobalt
Cr	Chromium
Cs	Cesium
Cu	Copper
Dy	Dysprosium
Er	Erbium
Fe	Iron
Ga	Gallium
Gd	Gadolinium
GIS	Geographic Information System
Hf	Hafnium
Hg	Mercury
Ho	Holmium
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
K	Potassium
La	Lanthanum
Li	Lithium
LOD	Limit of detection
Lu	Lutetium
Mg	Magnesium
Mn	Manganese
Mo	Molybdenum
Na	Sodium
Nd	Neodymium
Ni	Nickel
NOF	The Norwegian ornithological society
NINA	Norwegian institute for nature research
P	Phosphorus
Pb	Lead
PCA	Principal component analysis
Pr	Praseodymium
Rb	Rubidium
REE	Rear earth elements
S	Sulfur
Sb	Antimony
Sc	Scandium
Se	Selenium
Si	Silicon
Sm|	Samarium
Sn	Tin
Sr	Strontium
Tb	Terbium
Th	Thorium
Ti	Titanium
Tl	Thallium
U	Uranium
V	Vanadium
W	Tungsten
Y	Yttrium
Yb	Ytterbium
Zn	Zinc

1 Introduction

1.1 Biomonitoring

The increasing incidence of organic pollutants and metal emissions to the environment associated with rapid growth in human population, technological development and industrialization poses a serious risk to humans and wildlife (Connell *et al.*, 1999; Flora, 2014). As a consequence, many monitoring programs have been developed and proven to be useful tools in assessing environmental exposure of pollutants (Sexton *et al.*, 2004). It is difficult to evaluate the impact of pollutants on organisms only by measuring concentrations in the environment (Connell *et al.*, 1999). Therefore, measurements of the concentration of pollutants in living organisms is a more commonly applied method. The advantage of using living organisms for biomonitoring is that concentrations within the samples will reveal all routes of repeated exposure. Whether exposure is through the respiratory tract, the gastrointestinal tract or through dermal contact biomonitoring will show if, and to what extent, the organisms have been exposed (Sexton *et al.*, 2004). By understanding the chemical and physical properties of a particular pollutant, it is possible to choose the appropriate tissue or fluid to analyze concentrations of pollutants and to measure the effects they induce within an organism.

1.1.1 Birds as biomonitoring tools

Birds in particular are useful organisms in monitoring pollutants in the biological environment (Burger, 1993; Furness & Greenwood, 1993; O'Sullivan & Sandau, 2014). They are easy to observe, very sensitive to environmental changes and they might accumulate large and harmful amounts of environmental pollutants. Since many birds feed at high trophic levels, biomonitoring of avian tissues can reflect pollutant hazards to humans more closely than e.g. samples from most invertebrates. In addition, the ecology, physiology and behavior of birds are well studied. Birds are mainly exposed to pollutants through ingestion of contaminated food and water (Seco Pon *et al.*, 2011). Many pollutants can subsequently bioaccumulate in different body tissues of the birds such as in blood, feathers, liver, kidney, brain, muscle and bone.

1.1.2 Feathers and accumulations of pollutants

Feathers are simple to collect, store, transport and use for analysis of pollutants without causing any damage to the birds, and they have many advantages that make them excellent non-destructive tool (Borghesi *et al.*, 2016; Furness & Greenwood, 1993; García-Fernández *et al.*, 2013; O'Sullivan & Sandau, 2014). Some metals will be transferred into growing feathers proportionally to the blood level, and a relatively high amount of certain elements (e.g. Hg and As) are stored in feathers (Barbieri *et al.*, 2010; Borghesi *et al.*, 2016).

Several routes contribute to the accumulation of pollutants in feathers. First, there is an internal assimilation through uptake of pollutants during feather growth as the feather is still connected to the bloodstream, and pollutants such as metals will interact with the keratin structure of the feathers (Burger, 1993; Ghosh & Collie, 2014; Tsipoura, 2008). After a feather is fully developed, it will disconnect from the physiological processes in the body (Denneman & Douben, 1993). In this way birds are able to excrete a substantial level of certain metals through feathers during molting, and the molted feathers will serve as an archive of the metal levels in the bloodstream during the feather formation (Burger, 1993). The other routes that contribute to the level of pollutants in feathers, besides internal uptake, is direct atmospheric deposition and deposition from dust and sediments onto feathers, since they effectively absorb toxic pollutants from the environment (Borghesi *et al.*, 2016). In addition, there is a deposition of pollutants onto feathers through the preening process (Borghesi *et al.*, 2016; Dauwe *et al.*, 2003; Ghosh & Collie, 2014; Jaspers *et al.*, 2004). At a certain threshold all metals, biologically essential or not, will act as toxic to organisms (Burger, 1993).

The toxic concentration threshold for lethal or sublethal effect varies for different bird species and each particular metal. In addition, it depends upon the route and dose of exposure and the physical condition of the individual being exposed. Therefore, there are some challenges related to sampling of feathers. These challenges are often linked to sex and age differences among the monitored individuals, or to sampling problems connected to the use of dead or live birds or related to the selection of feather type and sufficient sample size (Burger, 1993; Peterson *et al.*, 2019). The time of sampling is another important factor as seasons and moult stage can have a strong influence on the levels of contaminants in the feathers. In addition, using feathers to monitor e.g. Hg and compare Hg contamination among studies can be biased by the methods employed during feather collection, because Hg concentrations can vary substantially among feather components within individual feathers (Peterson *et al.*, 2019). Variability in Hg concentrations within and among individual feathers from the same bird combined with

differences in feather collection methods can limit the interpretability of a study. Lower variability of Hg concentrations among individual whole body feathers makes body feathers preferable to wing and tail feathers for most Hg studies in birds (Peterson *et al.*, 2019).

In order to use feathers as tools to reveal concentrations of metals from previous contamination, the measurements should indicate a consistent relationship with current levels in other tissues of the birds (liver, kidney, brain, blood, muscle and bone). When a metal enters an organism it could either be stored in tissue or excreted, and birds have the possibility to eliminate some metals by depositing them during feather growth. In addition, several studies have demonstrated that females can transfer some heavy metals into her eggs, and females with a heavy burden of certain metals sequester higher levels of metals into their eggs than females with lower levels (Burger & Gochfeld, 1991; Hernández *et al.*, 1999). Such deposition can affect the developing embryo.

Birds are often very mobile and this could be challenging when birds are used as biomonitoring species since they may be exposed to pollutants from a large and often undefined area (Furness & Greenwood, 1993). This could in some cases make point source determinations difficult (Burger, 1993). In addition, many bird species often have a long lifetime so the history of the pollutant burdens may be complex (Furness & Greenwood, 1993). They also tend to be challenging to sample. On the other hand, some of these challenges may be positive for biomonitoring purposes, if the monitoring species are chosen carefully. Biomonitoring of birds over long timescales and large areas may give useful information about pollutant trends (Bustnes *et al.*, 2013; Dolan *et al.*, 2017). Birds reflect spatial variations in contamination level in addition to the pollutant level in the whole ecosystem (Burger, 1993). Some bird species, however, do not migrate and stay in their territory throughout the year. Stationary birds, and their offspring that stay in the territory until they disperse, are completely dependent on the local environment for food, and can be used to monitor contamination in a more local ecosystem (Burger, 1993; Peterson *et al.*, 2019). For many bird species, the home-range during the breeding season is well known, and this makes it possible to calculate an exposure range (Burger, 1993).

1.1.3 The use of predatory birds as biomonitoring tools

Biomonitoring of birds of prey is of particular interest. Since birds of prey forage at the top of the food chain, they might be expected to bioaccumulate high levels of metals and other pollutants (Burger, 1993; Dauwe *et al.*, 2003). Historically, population declines were initially

observed in species at the top of the food chain, and raptors are especially vulnerable since toxic substances are accumulated along their food chain. Several studies have shown that tissue, blood and feathers from birds of prey can be useful matrixes for monitoring of heavy metals and organic pollutants (Abbasi *et al.*, 2015a; Battaglia *et al.*, 2005; Dolan *et al.*, 2017; Hahn *et al.*, 1993; Jaspers *et al.*, 2009; Jaspers *et al.*, 2004; Jaspers *et al.*, 2013; Jaspers *et al.*, 2006). A more recent study has investigated the relevance of using feathers in monitoring of both legacy pollutants and the emerging contaminants (Løseth *et al.*, 2019). It confirmed that use of feathers was successfully validated for legacy compounds, but for emerging contaminants, the suitability of using feathers seemed to be limited.

1.1.4 Tawny owls as a monitoring species

Tawny owl *(Strix aluco)* is medium-sized, broad winged, chiefly nocturnal owl with a body length of 37-39 cm, body weight of 385-800 g and a wingspan of 94-104 cm (Cramp, 1985). All body feathers are moulted once a year, while the wing feathers have a multi-annual moulting pattern (Solheim & Vedum, 2017). Tawny owls remain within a restricted territory throughout the year. This makes them very suitable for monitoring of pollutants in local terrestrial ecosystems. Both sexes stay in their territory and defend it strongly against other owls (Mikkola, 1983). They require structured habitat with plenty of look-out posts for hunting, and operate mostly in deciduous or mixed woodlands, mainly in lowland (Cramp, 1985). The diet consists mainly of rodents and passerine birds, but they can also feed on hares, frogs and other small animals such as shrews, earthworms and beetles. Normally, breeding tawny owls choose natural holes or nest boxes in trees (Mikkola, 1983). In Scandinavia, they usually start breeding in the end of March or early April. The onset of breeding could be affected by climatic conditions and variances in the occurrence of rodents. They usually lay 2-4 eggs, which are incubated for 28-30 days (Olsen, 2007). Normally, eggs are laid at intervals of 48 hours and are incubated only by the female (Mikkola, 1983). It is easiest to catch the female during the incubation period since she is then strongly attached to her eggs. During the first 6-7 days of hatching, the male brings food to the nest, but afterwards the female starts to hunt. Fledging occurs after 28-37 days, but the young tawny owls are dependent on their parents for food up to three months after leaving the nest. Tawny owls are known to be highly sedentary, and during their first year of life the young owls try to establish territories near the territory where they were born (Mikkola, 1983). They are potentially long-lived birds, and the maximum life span registered in the wild is 19 years (Olsen, 2007).

1.2 Metals and other elements as pollutants

Metals are naturally occurring components in the environment as being constituents of the earth's crust (Singh *et al.*, 2011). It is impossible to live in an environment free of metals; however, anthropogenic activities have disturbed the natural biochemical balance and the geochemical cycles and have contributed to making metals more available for exposure to organisms and uptake in biota (Casarett & Doull, 2013; Singh *et al.*, 2011). A toxicologically important characteristic of metals is that they often react in biological systems by losing electrons to form cations (Casarett & Doull, 2013). The exact chemical basis of metal toxicity is not very well understood, but metals in their ionic form can be very reactive and have the ability to interact with biological systems in many different ways (Casarett & Doull, 2013). Many of the metals are essential to life and play a crucial role in various vital functions, participating in important metabolic and signaling pathways in living biological systems (Flora, 2014; Valko *et al.*, 2005). In addition, metals have contributed enormously to economic development and advances in various fields such as health care, construction and communications. Certain metals have proven to be potentially toxic in low concentrations and pose a threat to all life forms (Flora, 2014). Metals accumulate and disrupt the metabolic function of vital organs and glands (Singh *et al.*, 2011). They mimic vital nutritional minerals and disturb their natural function. Metals and metalloids are considered contaminants if they exist in environments where they naturally do not occur, or exist in unnatural forms and concentrations that pose detrimental effect to humans and environment (Singh *et al.*, 2011). Excessive levels of metals can be damaging to an organism, as all metals are considered toxic at higher concentrations. Unlike many other chemicals, metals cannot be metabolized into less toxic compounds (Casarett & Doull, 2013; Koivula & Eeva, 2010). Organisms have developed important mechanisms, such as antioxidant defenses, which detoxify and remove harmful compounds from the body, to protect themselves against toxic organic and inorganic compounds.

1.2.1 Trace elements

Trace elements were first described as elements present at very low quantities in different matrices (Chojnacka & Saeid, 2018). There are different understandings of trace elements in different branches of science, and the word "trace" is usually related to abundance. In geochemistry trace elements are elements that are present in the earth's crust in amounts of less

than 0,1%, and in biological science it refers to elements in trace concentrations in living organisms (Chojnacka & Saeid, 2018; Shaheen *et al.*, 2013). Based on these differences, there is no precise definition of trace elements in the terrestrial environment. For example, elements defined as trace in biological materials will not necessary be defined as trace in the terrestrial environment (e.g. iron). Trace elements can have significant effects on living organisms, and it is known that they can have essential, neutral or detrimental effects. Their property relies on their possibility to form complexes and chemical bonds with macromolecules in organisms. Frequently mentioned trace elements and micronutrients are: Cr, Co, Cu, F, I, Mn, Mo, Se, V and Zn (Chojnacka & Saeid, 2018). Some of the trace elements are essential to the organism while some of the nonessential elements have potentially toxic effects. Trace elements that can cause harmful environmental pollution have generated a need for developing suitably sensitive, rapid, effective and reliable analytical methods (Chojnacka & Saeid, 2018). Several analytical methods have been developed to monitor trace elements in environmental samples. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) is one of the methods developed for analysis of trace elements. This method enables analysis of multiple elements at high sensitivity (Li *et al.*, 2016).

1.2.2 Toxic metals and metalloids

The toxicity of trace elements is not only dependent on their concentration but also on the type of element (Chojnacka & Saeid, 2018). Major toxic metals are Arsenic (As), Beryllium (Be), Cadmium (Cd), Chromium (Cr), Lead (Pb), Mercury (Hg) and Nickel (Ni) (Casarett & Doull, 2013). Essential metals with potential for toxicity are Cobalt (Co), Copper (Cu), Iron (Fe), Magnesium (Mg), Manganese (Mn), Molybdenum (Mo), Selenium (Se), Trivalent Chromium (Cr^{3+}) and Zink (Zn) (Casarett & Doull, 2013). Minor toxic metals are Antimony (Sb), Barium (Ba), Cesium (Cs), Fluorine (F) (nonmetallic), Germanium (Ge), Indium (In), Palladium (Pd), Silver (Ag), Tellurium (Te), Thallium (Tl), Tin (Sn), Titanium (Ti), Uranium (U) and Vanadium (V) (Casarett & Doull, 2013). Metals that pose a threat to the environment under certain conditions (e.g. long time exposure, acidic conditions etc.) include of Aluminum (Al), Bismuth (Bi), Gallium (Ga), Gold (Au), Lithium (Li) and Platinum (Pt) (Casarett & Doull, 2013).

1.2.3 Effects of toxic elements

Experimental evidence has shown that increases in reactive oxygen in cells, through either physiological or chemical carcinogen exposure, contribute to oxidative stress and to the carcinogenesis processes (Casarett & Doull, 2013). A series of oxygen radicals are produced by reduction of molecular oxygen by both endogenous and exogenous sources. Reactive oxygen species consist of reactive compounds including the superoxide anion ($\cdot O_2^-$), hydroperoxyl radical ($HO_2\cdot$), hydrogen peroxide (H_2O_2) and the hydroxyl radical ($\cdot OH$) (Casarett & Doull, 2013). Of the radicals produced, all except H_2O_2 are sufficiently reactive to interact with biomolecules. Within the mitochondria, a small percentage of oxygen is converted into the superoxide anion via one-electron reduction of molecular oxygen. Superoxide can be converted into hydrogen peroxide by the enzymatic activity of superoxide dismutase. In the presence of partially reduced metal ions, hydrogen peroxide is converted into the highly reactive hydroxyl radical through Fenton and Haber Weiss reactions (Casarett & Doull, 2013). Oxygen radicals are counterbalanced by antioxidants, both enzymatic (e.g. superoxide dismutase, glutathione peroxidase, and catalase) and non-enzymatic (e.g. vitamin E, vitamin C, β-carotene, melatonin and glutathione). In sufficient amounts, the antioxidants can prevent the majority of metal-mediated (iron, copper, cadmium) damage, both in *in vitro* systems and in metal-loaded animals (Casarett & Doull, 2013; Valko *et al.*, 2005). Inadequate supply of antioxidants results in damage to cellular biomolecules and the metal-mediated formation of free radicals causes various modifications to DNA bases, enhanced lipid peroxidation, and altered calcium and sulfhydryl homeostasis. (Valko *et al.*, 2005). Lipid peroxides can further react with redox metals finally producing mutagenic and carcinogenic DNA adducts. Metals such as iron (Fe), copper (Cu), chromium (Cr), vanadium (V) and cobalt (Co) will undergo redox-cycling reactions. For mercury (Hg), cadmium (Cd) and nickel (Ni), the primary route for their toxicity is depletion of the antioxidant glutathione and bonding to sulfhydryl groups of proteins. Arsenic (As) is thought to bind directly to critical thiols (Valko *et al.*, 2005).

1.3 Aim of study

Because there is limited data available on potential impacts of toxic elements in terrestrial ecosystems in Central Norway, the aim of the present study was to investigate the presence and concentrations of a wide range of essential and non-essential trace elements in Tawny owls. I wanted to study the contamination in this avian top predator by using blood and feather samples from adult females and their nestlings. Since tawny owls remain within a restricted territory throughout the year, each individual is expected to reflect the elemental concentrations in its territory and thus to describe possible elemental pollution in its local environment.

The concentrations of elements were determined in blood and feathers from adult and nestling tawny owls to:

1. Compare the concentrations of elements between feathers and blood.

   I hypothesized that I would find a positive correlation between concentrations of elements in blood and feathers in nestlings, and to some extent in adults, due to transfer from the blood to the growing feathers. For some elements, however, the concentrations in feathers were expected to be influenced by external contamination, thus showing weaker or no significant correlations depending on the extent of external contamination.

2. Compare elemental concentrations between adult females and their nestlings.

   I hypothesized that I would find a positive correlation between concentrations of elements in blood and feathers for some of the elements due to maternal transfer from females to nestlings via the egg. In addition, it was hypothesized that there would be higher concentrations of several elements in adult females compared to their nestlings since adults have had more time to bioaccumulate contaminants compared to nestlings.

3. Compare elemental concentrations in relation to habitat variations in tawny owls inhabiting different territories in Central Norway.

   I hypothesized that I would find positive correlations in concentrations of some elements in relation to the area of different land use, such as settlements, agricultural land, freshwater lakes and forest, since increased anthropogenic activities have made metals and other elements more available for exposure to organisms.

2 Method

2.1 Study area

This study was carried out in the north eastern parts of Trondheimsfjorden (64°N, 11°E) in Central Norway from 2016 to 2018, in the municipalities of Verran, Steinkjer, Inderøy, Verdal and Levanger including Ytterøy – an island in Levanger (Figure 1). The nest sites of tawny owls are mainly connected to cultural landscapes, and consist of agricultural landscapes, scattered settlements, small towns, some industrial areas and a network of roads. The elevation of the nest boxes in this study were all below 200 meters above sea level, and the nest boxes were near the fjord. The study area represents the northern boundary of the distribution range for tawny owls in Europe (Cramp, 1985; Olsen, 2007; Sunde *et al.*, 2001).

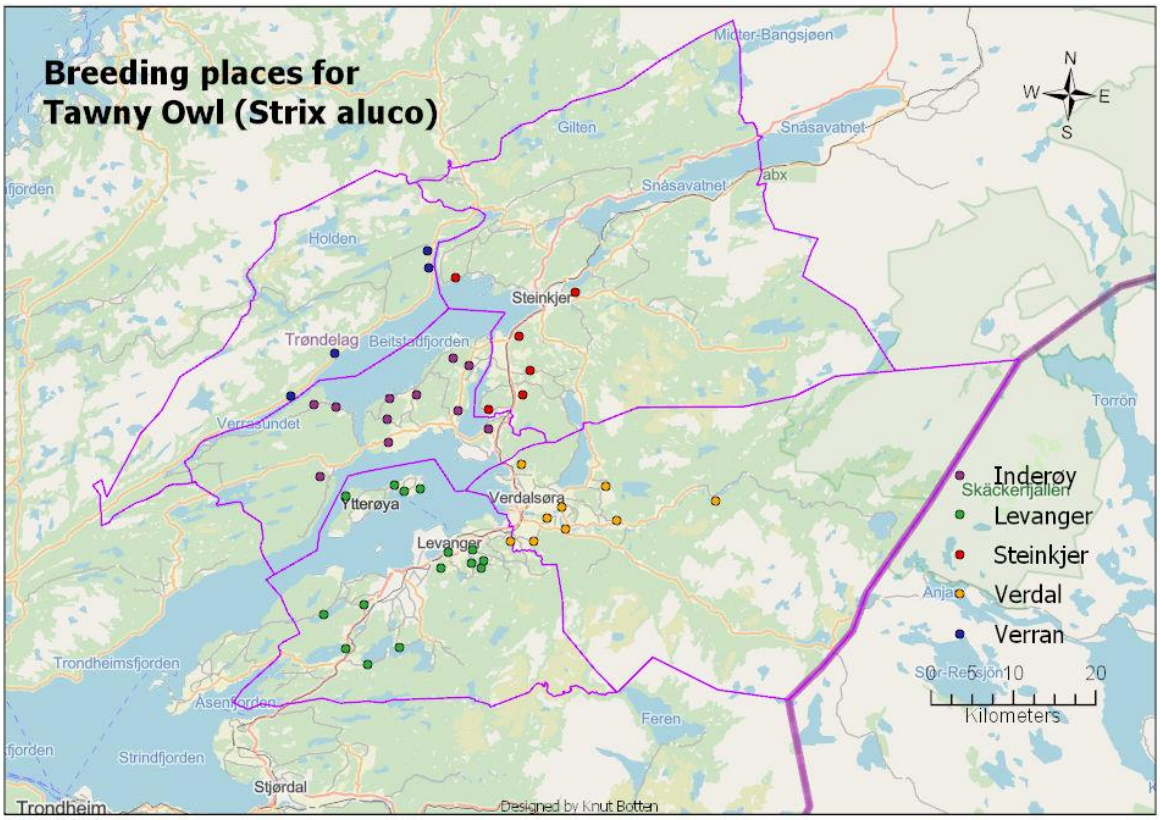

Figure 1. Overview of the 45 sampling localities included in the study. The breeding territories are situated in five different municipalities

2.1.1 Monitoring program of tawny owls in central Norway

The annual monitoring program for tawny owl in Central Norway has been accomplished by the Norwegian Ornithological Society (NOF) since the early 1980s. During four decades of monitoring, NOF has established many productive nest boxes in appropriate habitats for tawny owls in Central Norway. Normally, it can be challenging to catch sufficient individuals of a particular raptor species for pollutant analyzes. The monitoring program of tawny owls in Central Norway enables access to many individuals within a restricted area. As levels of pollutants can be related to local exposure it is therefore possible to investigate the environmental contamination in the local area.

2.2 Capture and sampling

We visited 60 nest boxes during the field season of 2016 and approximately 70 nest boxes in both 2017 and 2018 (45 hatchings). In 2016, as a pilot study we sampled only feathers from adult owls. In 2017 and 2018, we sampled blood and feathers from both adult owls and their offspring. The nest boxes were visited once during the breeding season of 2016, and twice during each breeding season of 2017 and 2018.

The first visit, which included capturing and sampling of blood and feathers from the female, was performed during the incubation period from approximately 20th of April to the first week of May. Samples from nestlings were collected during the second visit, from approximately 20th of May to the first week of June, i.e. when the nestlings were two-three weeks old (for more precise sampling locations see Table A18, Appendix). Permission to use tawny owls in this project was given by the Norwegian Food Safety authority (Mattilsynet: FOTS ID 12024).

During the breeding seasons of 2016 – 2018, the incubating female owls were captured with a net (n=72). Experienced personnel from NOF did the climbing and the capturing of adult owls. Blood samples (range of 26-860 mg) and feathers samples (approximately 20-40 pieces) were collected simultaneously from the females in 2017 and 2018. Feather samples (n=72) were taken from the lower part of the chest, near the incubating spot, and immediately placed in a zip bag. The blood samples (n=28) were taken from the wing vein using a pre-heparinized sterile 2 ml BD Plastipak syringe (REF 300185) with a 0,6x25 mm BD Microlance 3 23G nr.16 (REF 300800), and transferred to a marked Eppendorf tube.

Feather samples (6-20 pieces) from nestlings were taken from the back where the feather formation is most developed (n=61). Blood samples (range of 103-836 mg) were collected from

the wing vein of the nestlings (n=35, 20 females and 15 males) using a pre-heparinized sterile syringe (the same type used for the mother), for determination of the elemental concentrations. The blood samples were only taken from the heaviest nestling in each clutch. In addition, a small blood sample was taken with a capillary tube from all the offspring in the clutch for gender determinations. Feathers (6-20 pieces) were taken from all the nestlings in 2017 and from the heaviest nestling in each clutch in 2018.

The blood and feather samples for elemental determinations were frozen at -20 °C from the day of sampling until the elemental analysis was performed. Blood taken with a capillary tube for determining the gender of the nestlings was transferred to a lysis-buffer and kept cold in a refrigerator (4°C) until genetic analysis of the sex. Body weight and wing length of the female were recorded together with the weight of the nestlings. The number of eggs and the clutch size were also noted.

2.3 Feather analysis

To remove external contamination from the feathers, a washing procedure was performed at the department of biology at NTNU, prior to the elemental analysis. The cleaning procedure is similar to the washing process described in Cardiel *et al.* (2011), with minor modifications. This procedure consisted of five main steps. All the equipment and glassware used in the procedure were washed in 50% (v/v) HNO_3 prior to analysis. Before the washing procedure, feathers from each owl were transferred to 50 ml pp tubes using Teflon forceps. The forceps were covered with a new plastic film for each sample to avoid contamination between samples. During the five following steps a volume of approximately 25 – 30 ml of ultra-pure water (milli Q), acetone and acid (HNO_3) were used, depending on the size and amount of feathers. In the first washing step, feathers were soaked in acetone and carefully shaken for 5 minutes**.** The feathers were flushed with ultra-pure water twice to remove the excess of acetone, followed by a second step which included a wash and gentle shaking with ultra-pure water for 5 minutes. In the third step, the feathers were washed and shaken once more in acetone for 5 minutes, the same way as in the first step. The feathers were flushed with ultra-pure water twice to remove the excess of acetone. In the fourth step, the feathers were washed and shaken in 2% v/v ultra-pure grade HNO_3 for 5 minutes, and flushed with ultra-pure water twice. The fifth and final step consisted of a wash and shake with ultra-pure water for 5 minutes. During all the washing steps, a shake table was used to effectively wash feathers from different individuals at the same

time (e.g. 71 samples were shaken simultaneously during all the steps of the washing procedure in 2017).

After the washing procedure, feathers from the pilot season (2016) were dried in a drying cabinet for 24 hours following a drying period at room temperature for five days, while they were covered with filter paper. Feathers from 2017 and 2018 were freeze-dried in a Christ freeze-drier for 15 hours at the department of chemistry, NTNU. The procedure was optimized between the pilot season of 2016 and the sampling years of 2017/2018, as the initial drying period was too long. The new procedure included using a freeze dryer, which seemed a highly effective way of rapidly drying large amount of feathers from many different individuals.

The preparations for the ICP-MS analysis were performed immediately after the drying procedure. Before analysis the feathers were first weighed in Teflon tubes and digested with 6 ml 50% v/v HNO_3 in an Ultra Clave from Milestone for 2,5 hours according to the temperature profile shown in Figure A1 and Table A1, in Appendix. After the digestion the fluid was transferred to a 15 ml PP-vial after first being diluted in a PFA-bottle to 58-62 g, with ultra-pure water (the exact weight for each sample was noted). The final concentration of acid was 0,6M HNO_3.

The feathers were analyzed for 56, 58 and 62 different elements in 2016, 2017 and 2018, respectively, by the method of inductively coupled plasma mass spectrometry (ICP-MS). Blank samples were included in all analyses to assess any contamination from the sample preparation procedure. They were treated in the same way as the samples, except that they were just ultrapure water and 6 ml 50% HNO_3. Specification of analyzed elements is given in table 1, appendix A. In 2016 certified reference material from the Institute of Nuclear Chemistry and Technology Warsaw – Poland, Oriental Basma Tobacco Leaves (INCL-OBTL-5), was used in the analysis of the feathers. In 2017 and 2018 certified reference material from the Institute of Geophysical and Geochemical Exploration Langfang – China, Chicken GBW-10018, was used as reference material in the feather analysis.

2.4 Blood analysis

To minimize contamination, the blood samples were poured directly into Teflon tubes, weighed, and then digested with approximately 2 times the blood volume using 1,5 ml concentrated HNO_3. The blood samples were digested in an Ultra Clave from Milestone for 2,5 hours according to the temperature profile shown in Figure A1 and table A1, in Appendix. After

digestion the fluid was transferred to a 15 ml PP-vial after being diluted in a PFA-bottle to 25-28 g with ultrapure water (the exact weight for each sample was noted). The final concentration of acid was 0,6 M HNO_3. The blood samples were tested for 56, 58 and 62 different elements in 2016, 2017 and 2018, respectively, using an ICP-MS. Specification of elements analyzed is given in table 1, appendix A. As reference material for the blood analysis, Seronorm Trace elements Serum L-1, Lot 0608414, was used.

2.5 GIS analysis

A landscape analysis of the habitats was performed using ArcMap 10.4.1. The GIS-tool was used to process data and information from the territories, to get a more precise description of the landscape. The size of the territories used as basis for the analysis was limited to a radius of 1 km from the nest boxes. This was based on previous studies of movements of radio telemetry marked tawny owls (Overskaug *et al.*, 1999; Sunde *et al.*, 2001)

Two datasets were used to generate the results, FKB-AR5 and point data of nest localities. The FKB-AR5 is a data set that is a part of the Common Map database (FKB – Felles Kartdatabase) and the Public Map basis (det Offentlige Kartgrunnlaget). AR5 is a data set that contains detailed information of the area of Norway's land resources.

The GIS analysis was performed as a part of a bachelor thesis at Nord University (Hovd, 2018), where the same data were used for composition studies of the habitats of tawny owls in a bachelor thesis in nature management.

The different landscape parameters used were agricultural land, forest, settlements, freshwater lakes, ocean, bogs and other land (football fields, mountains and rocks etc.). They were all measured in square meters (m^2) within the territory. In addition, distance to industry, roads and oceans were analyzed in a pollution source distance analysis. They were measured in meters (m) from the nest box.

2.6 Statistics

All the elemental concentrations were calculated in relation to the weight of undiluted blood samples, or dry weight for feathers, and corrected for blank samples (Table A19 -Table A23, Appendix). The limit of detection (LOD) of the analysis method of the ICP-MS was determined as the highest value of the instrumental detection limit for each element, or 3 times the standard

deviation of the blank. All elemental values below limit of detection were replaced with a number that was calculated as the percent of elements above LOD for each type of element, divided by 100 and multiplied with the limit of quantification (LOQ) for each weight class of the samples (%>LOD)/100)*LOQ. If 50% or more of the elements from 2016-2018 were below limit of detection, the elements were removed from the statistical analysis. This was done for adults and nestlings combined and for each of them separately. For feathers of nestlings and adults combined, 49 of the elements were above limit of detection for all three years combined. In feathers of adults and nestlings separately 52 and 48 of the elements were above limit of detection, respectively. In blood of nestlings and adults combined, 39 elements were above limit of detection for 2017 and 2018 combined. In blood of adults and nestlings separately 40 and 38 elements were above limit of detection, respectively. Paired t-tests were performed to establish if there were significant differences between elemental blood levels and elemental levels in feathers for both adults and nestlings. The data was first tested for normality using Shapiro Wilks Normality Test. If the normality test failed, a Wilcoxon Signed Rank Test was performed. The significant level was set to 0,05.

Multivariate analysis was performed by running a Principal Component Analysis (PCA) by using the statistical program Simca 15. In the principal component analysis, all the detectable elemental concentrations of adult feather samples (n=72) and adult blood samples (n=28), nestling feather samples (n=61) and nestling blood samples (n=35) were used in the analysis. Data were log transformed before running the PCA.

To test further for correlation and statistical significance the statistical software of Sigma Plot 14 was used. For correlation analysis in feather vs. blood, and in adult vs. nestlings, and among adults/nestlings vs. the different landscape types, a correlation coefficient and a corresponding p-value were calculated using Pearson Correlation analysis. Correlations are visualized as scatter plots for some of the elements with highest correlation coefficient (r) and statistical significance levels ($p<0,05$). A Bonferroni correction was not applied when comparing associations between multiple variables because of the increased probability of producing false negatives (Moran, 2003).

3 Results

3.1 Comparison of concentrations of elements in feathers and blood

3.1.1 Adults

The elemental concentrations (min-max, mean ± SD) of all the adult blood samples (n=28) and adult feather samples (n=72) are shown in Table 1.

Several elements (n=30) are present at higher mean concentration in feathers compared with blood ($p<0,001$), e.g. Al, As, Cr, Cu, Hg, S, Se, Si, Zn. Other elements are present at higher mean concentration in blood (n=6) compare with mean concentration in feathers ($p<0,001$), e.g. Fe, K, Mg, Na, P, Rb.

Table 1. Elemental concentrations (min-max, mean±SD) in blood (n=28) and feathers (n=72) of adult tawny owls for 40 and 52 elements, respectively. Significant differences in elemental concentrations between blood and feather samples (n=28) were tested in cases where there were samples of both blood and feathers (paired t-test*, or Wilcoxon Signed Ranked test if normality test (Shapiro-Wilks) failed). ND =<50% LOD.

	Adult blood					Adult feathers						
	concentrations µg/g					concentrations µg/g					paired t-test	
Elements	*n*	min.	max.	mean µg/g	SD	*n*	min	max	mean µg/g	SD	*n*	*p*
Ag				ND		72	0,002	0,044	0,009	0,008		
Al	28	0,158	16,50	1,288	3,120	72	1,633	932,08	45,27	117,79	28	**<0,001**
As	28	0,004	0,037	0,010	0,008	72	0,006	0,411	0,038	0,061	28	**<0,001**
Au	28	8,3E-05	7,7E-04	2,3E-04	1,5E-04	72	4,9E-04	0,056	0,010	0,012	28	**<0,001**
B	28	0,043	0,695	0,277	0,156	72	0,048	0,525	0,246	0,070	28	0,59*
Ba	28	0,012	0,492	0,104	0,108	72	0,016	4,949	0,299	0,631	28	**0,022**
Bi	28			ND		72	0,001	0,172	0,007	0,022		
Ca	28	18,72	66,29	43,64	11,29	72	3,68	419,86	56,77	87,35	28	0,119
Cd	28	1,5E-04	0,003	6,0E-04	0,001	72	1,1E-04	0,048	0,002	0,006	28	**0,037**
Ce	28	9,4E-05	0,011	0,001	0,002	72	0,003	0,820	0,043	0,103	28	**<0,001**
Co	28	0,002	0,026	0,010	0,007	72	0,004	0,340	0,040	0,057	28	**<0,001**
Cr	28	8,6E-04	0,083	0,011	0,018	72	0,022	1,651	0,141	0,208	28	**<0,001**
Cs	28	3,5E-04	0,014	0,002	0,003	72	1,4E-04	0,048	0,003	0,006	28	0,864
Cu	28	0,133	0,584	0,292	0,085	72	0,912	9,607	3,083	1,009	28	**<0,001**
Dy	28			ND		72	1,9E-04	0,057	0,003	0,007		
Er	28			ND		72	1,6E-04	0,034	0,002	0,004		
Fe	28	101,10	551,37	303,63	89,88	72	2,862	730,0	41,66	88,97	28	**<0,001***
Ga	28			ND		72	0,001	0,242	0,012	0,030		
Gd	28	5,5E-06	0,002	2,1E-04	4,6E-04	72	ND					
Hf	28			ND		72	1,1E-04	0,020	0,001	0,002		
Hg	28	0,021	0,291	0,069	0,052	72	0,176	2,054	1,054	0,399	28	**<0,001***
Ho	28			ND		72	4,6E-05	0,012	0,001	0,001		
K	28	550,17	1923,06	1151,87	284,78	72	1,157	237,58	15,59	30,55	28	**<0,001***
La	28	5,5E-05	0,006	0,001	0,001	72	0,002	0,372	0,020	0,046	28	**<0,001**
Li	28	0,001	0,017	0,004	0,004	72	ND					
Lu	28			ND		72	1,9E-05	0,004	2,2E-04	0,001		
Mg	28	23,62	79,78	51,45	11,67	72	1,864	354,62	24,77	44,97	28	**<0,001**
Mn	28	0,011	0,202	0,039	0,040	72	0,045	13,18	0,861	2,035	28	**<0,001**
Mo	28	0,010	0,041	0,026	0,008	72	0,027	2,718	0,144	0,314	28	**<0,001***
Na	28	1875	4719	2889	584	72	2,468	102,10	14,63	13,79	28	**<0,001***
Nd	28	4,6E-05	0,006	0,001	0,001	72	0,001	0,368	0,019	0,046	28	**<0,001**
Ni	28	0,003	0,058	0,009	0,011	72	0,005	0,720	0,067	0,102	28	**<0,001**
P	28	496,1	1536	918,2	215,2	72	21,02	124,40	79,84	17,06	28	**<0,001***
Pb	28	0,002	0,050	0,009	0,009	72	0,005	2,565	0,099	0,300	28	**<0,001**
Pr	28			ND		72	2,9E-04	0,095	0,005	0,012		
Rb	28	0,531	4,512	2,048	0,827	72	0,003	1,079	0,068	0,143	28	**<0,001***
S	28	1363	3150	2038	320,2	72	7789	28163	24716	3310	28	**<0,001**
Sb	28			ND		72	0,002	0,082	0,012	0,012		
Sc	28			ND		72	2,3E-04	0,332	0,011	0,040		
Se	28	0,144	1,029	0,388	0,162	72	0,319	1,817	1,174	0,268	28	**<0,001***
Si	28	1,637	36,93	5,987	6,449	72	6,731	1807	101,1	225,5	28	**<0,001**
Sm	28	5,9E-06	0,001	1,4E-04	2,6E-04	72	2,0E-04	0,072	0,004	0,009	28	**<0,001**
Sn	28			ND		72	0,002	0,324	0,022	0,039		
Sr	28	0,009	0,079	0,022	0,014	72	0,007	4,340	0,183	0,533	28	**<0,001**
Tb	28			ND		72	2,7E-05	0,010	0,001	0,001		
Th	28	5,9E-06	1,7E-03	2,2E-04	3,7E-04	72	1,2E-04	0,145	0,006	0,018	28	**<0,001**
Ti	28	0,002	0,947	0,075	0,188	72	0,144	68,20	3,391	8,550	28	**<0,001**
Tl	28	2,0E-05	2,4E-04	7,2E-05	4,6E-05	72	0,000	0,010	0,001	0,002	28	**<0,001**
U	28	2,5E-05	7,5E-04	9,1E-05	1,4E-04	72	0,000	0,043	0,003	0,005	28	**<0,001**
V	28	8,1E-04	0,073	0,008	0,014	72	0,006	2,357	0,101	0,287	28	**<0,001**
W	28	8,4E-06	0,001	1,7E-04	2,3E-04	72	0,001	0,515	0,017	0,061	28	**<0,001**
Y	28	4,5E-05	0,005	4,8E-04	9,2E-04	72	0,001	0,301	0,015	0,038	28	**<0,001**
Yb	28			ND		72	1,3E-04	0,030	0,002	0,004		
Zn	28	1,705	4,712	3,235	0,653	72	2,733	50,28	10,82	6,793	28	**<0,001**

For comparison of concentrations and profiles of elements in feathers and blood, all feather and blood samples were included in the Principal Component Analysis (PCA). Figure 2a shows the loading plot and Figure 2b the score plot of component one and two from the multivariate analysis. The three first components of the PCA (Table 2) explain 77.6% of the variation. PC1 describes 57,4% of the variation, and Figure 2b shows that there is a clear division between blood and feathers. PC2 and PC3 describe 15,6% and 4,62% respectively. All the three components are significant.

Table 2. Principal Component Analysis of elements in adult feathers and blood. The three first component are significant and explain 65,7% of the variation.

Component	R2X	R2X(cum)	Eigenvalue	Q2	Limit	Q2(cum)	Significance	Iterations
0	Cent.							
1	0.574	0.574	32.1	0.546	0.0274	0.546	R1	12
2	0.156	0.73	8.72	0.325	0.0278	0.693	R1	10
3	0.0462	0.776	2.59	0.0593	0.0282	0.711	R1	31
4	0.0285	0.804	1.6	-0.0624	0.0286	0.693	R2	77

a) b)

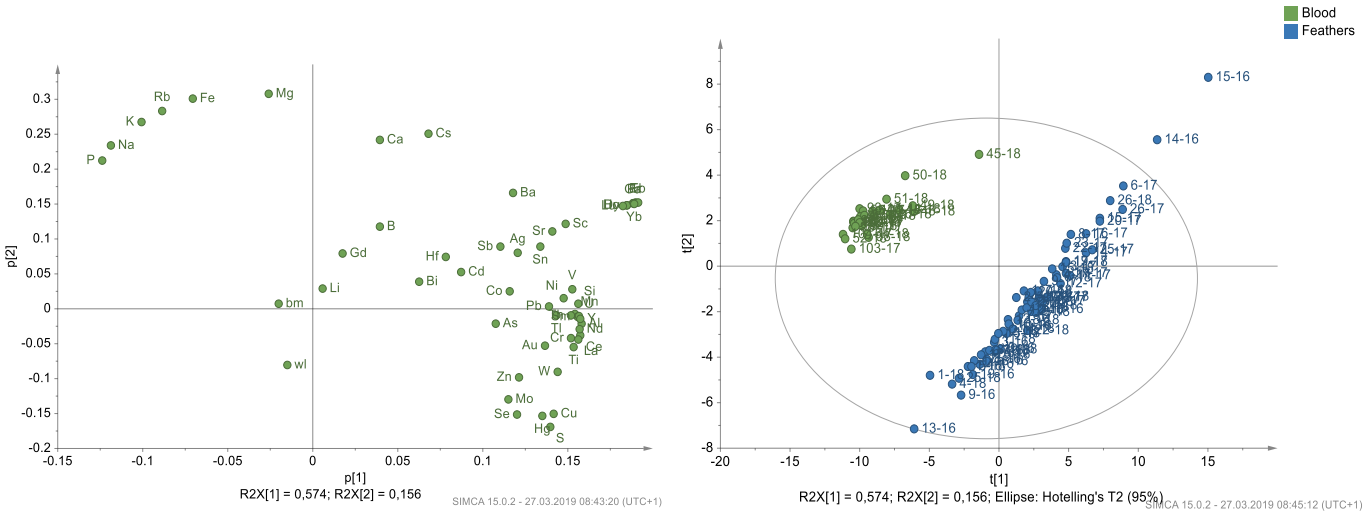

Figure 2. a) Loading plot and **b)** Score plot from the Principal Component Analysis of elements in adult feathers and blood. Hotelling's T2 ellipse (95%) with two outliers.

In figure 2a some of the elements (e.g. Fe, Na, Mg, K, Rb and P) cluster on the left side of the loading plot. The score plot in figure 2b shows that blood samples also cluster at the same side of the plot. This means that there are higher concentrations of these elements in blood.

Some of the rare earth elements (REE) cluster together in two groups on the right part of the loading plot and since those elements only had concentrations above limit of detection in feathers they will naturally be on the right side of the loading plot, where the feathers are also clustered in the score plot (Figure 2b).

Several elements (e.g. Cu, Zn, Hg and Mo) seem to cluster at the lower right part of the loading plot, and some elements cluster at the middle of the right side of the loading plot (e.g. As, Pb, Co, Cd, and Bi). Elements at the right side of the loading plot have higher concentrations in feathers than in blood as the score plot in figure 2b shows that also feather samples are clustered at the right side of the score plot.

In the Pearson correlation analysis, individuals used were limited to include only those where both blood and feather samples of the adult owls were available (n=28). The results from the correlation analysis show that there are significant positive correlations between blood and feather concentrations for two of the 38 elements (Hg and Mg) for the adult owls (Table 3). In addition, the analysis shows that there are significant negative correlations between blood and feather concentrations for four of the 38 elements (Au, B, Na and Th).

The concentrations of four elements with the highest correlations (Hg, Mg, Au and Na) in blood and feathers are shown in Figure 3.

Table 3. Pearson correlation analysis for concentrations of 38 elements in blood and feathers of adults (n=28). Significant correlations and *p*-values for the correlations are shown in bold.

blood - feathers adults			
Element	*n*	r	*p*
Al	28	-0,238	0,223
As	28	0,359	0,061
Au	28	**-0,484**	**0,009**
B	28	**-0,384**	**0,043**
Ba	28	-0,281	0,147
Ca	28	-0,063	0,750
Cd	28	0,177	0,367
Ce	28	-0,254	0,192
Co	28	0,101	0,610
Cr	28	-0,174	0,375
Cs	28	0,167	0,397
Cu	28	-0,128	0,515
Fe	28	0,293	0,131
Hg	28	**0,505**	**0,006**
K	28	0,311	0,107
La	28	-0,277	0,153
Mg	28	**0,437**	**0,020**
Mn	28	-0,235	0,230
Mo	28	0,072	0,717
Na	28	**-0,412**	**0,029**
Nd	28	-0,257	0,187
Ni	28	-0,181	0,357
P	28	0,236	0,226
Pb	28	0,037	0,854
Rb	28	0,114	0,562
S	28	-0,293	0,130
Se	28	0,005	0,980
Si	28	-0,249	0,202
Sm	28	-0,281	0,147
Sr	28	-0,260	0,182
Th	28	**-0,375**	**0,049**
Ti	28	-0,225	0,249
Tl	28	-0,027	0,891
U	28	-0,270	0,165
V	28	-0,215	0,271
W	28	-0,080	0,686
Y	28	-0,262	0,178
Zn	28	0,097	0,624

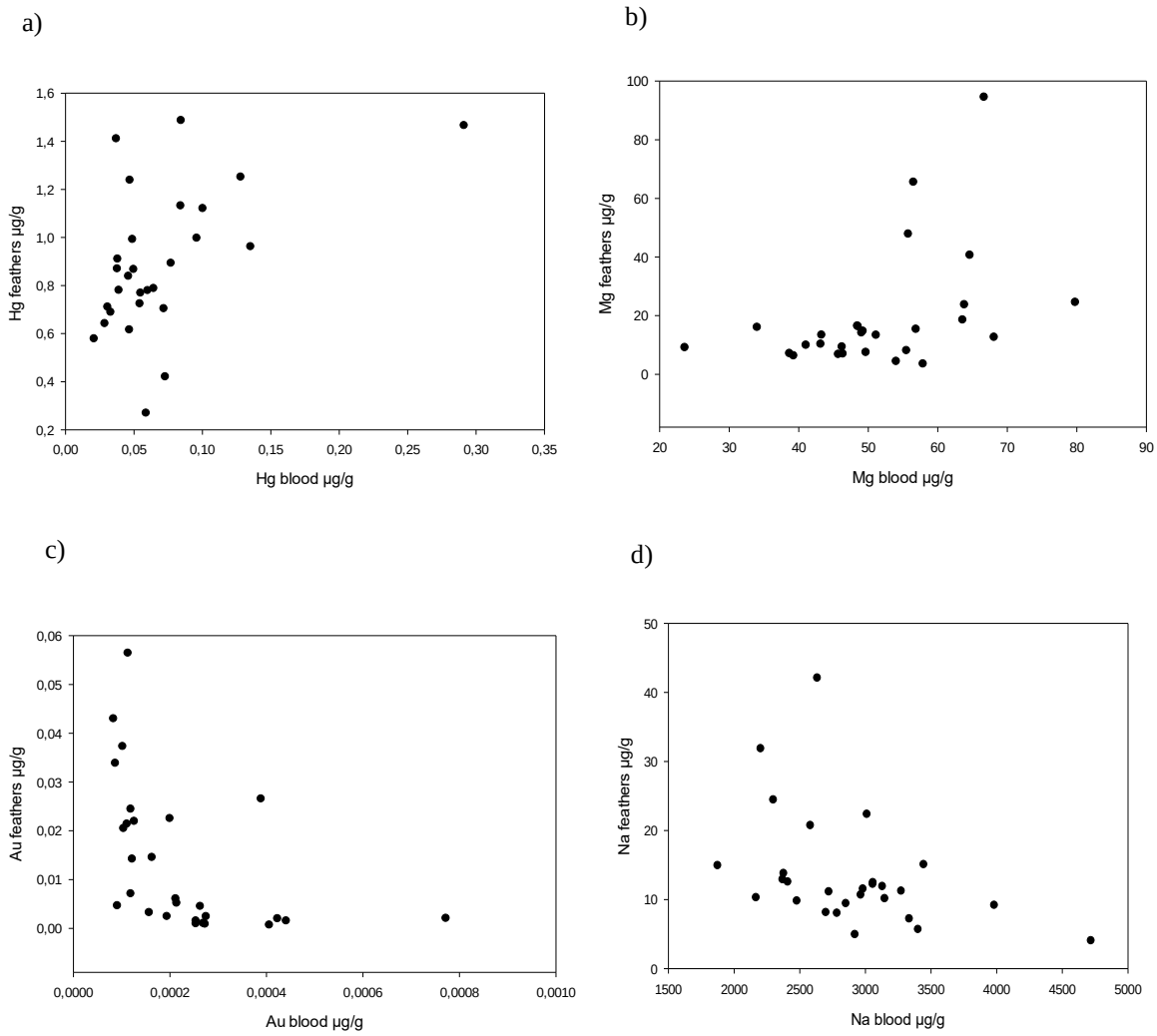

Figure 3. Relationship between elements in blood and feathers of adult owls (n=28). In **a)** a positive correlations for Hg (R^2=0,26, *p*=0,006), **b)** a positive correlations for Mg (R^2= 0,19, *p*= 0,02), **c)** a negative correlations for Au (R^2=0,23, *p*=0,009), and in **d)** a negative correlation for Na (R^2=0,17, *p*=0,029).

3.1.2 Nestlings

The elemental concentrations (min-max, mean ± SD) of all the nestling blood samples (n=35) and nestling feather samples (n=61) are shown in Table 4. Several elements (n=27) are present at higher mean concentration in feathers compared with blood (p<0,001), e.g. Al, As, Cr, Cu, Hg, Mg, Mn, Se, Si, Ti and Zn. Other elements are present at higher mean concentration in blood compared with feathers (p<0,001), e.g. B, Cs (*p*=0,008), Fe, K, Na, P and Rb.

Table 4. Elemental concentration (min-max, mean±SD), in blood (n=35) and feathers (n=61) of nestling tawny owls for 38 and 48 elements, respectively. Significant differences in elemental concentrations between blood and feather samples (n=33) were tested in cases where there were samples of both blood and feathers (paired t-test*, or Wilcoxon Signed Ranked test if normality test (Shapiro-Wilks) failed). ND =<50% LOD.

	Nestling blood					**Nestling feathers**						
	concentrations µg/g					concentrations µg/g					Paired t-test	
Elements	*n*	Min	max	mean µg/g	SD	*n*	min	Max	mean µg/g	SD	*n*	*P*
Al	35	0,043	1,466	0,434	0,343	61	1,399	56,22	11,58	9,986	33	**<0,001**
As	35	0,004	0,053	0,011	0,009	61	0,003	0,416	0,026	0,057	33	**0,005**
Au	35	5,8E-05	4,8E-04	1,7E-04	9,1E-05	61	3,5E-04	0,012	0,003	0,002	33	**<0,001**
B	35	0,034	0,912	0,291	0,212	61	0,065	0,692	0,138	0,106	33	**<0,001**
Ba	35	0,003	0,923	0,113	0,180	61	0,010	0,188	0,066	0,041	33	0,568*
Bi	35	ND				61	4,4E-04	0,005	0,001	0,001		
Ca	35	20,26	58,65	45,50	9,64	61	16,64	170,47	89,07	34,91	33	**<0,001**
Cd	35	4,1E-05	0,011	0,001	0,002	61	ND					
Ce	35	3,5E-05	0,001	2,5E-04	2,3E-04	61	0,001	0,035	0,009	0,007	33	**<0,001**
Co	35	0,004	0,030	0,015	0,007	61	0,008	0,054	0,017	0,010	33	0,417*
Cr	35	0,001	0,036	0,007	0,008	61	0,022	0,307	0,073	0,051	33	**<0,001**
Cs	35	2,0E-04	0,058	0,005	0,010	61	2,1E-04	0,009	0,001	0,001	33	**0,008**
Cu	35	0,059	0,389	0,154	0,054	61	0,922	3,259	1,883	0,410	33	**<0,001**
Dy	35	ND				61	1,4E-04	0,004	0,001	0,001		
Er	35	ND				61	8,3E-05	0,002	4,6E-04	3,9E-04		
Fe	35	76,78	309,6	205,9	56,67	61	6,816	85,23	18,42	10,75	33	**<0,001**
Gd	35	2,5E-06	3,0E-04	5,6E-05	5,9E-05	61	ND					
Hg	35	0,003	0,057	0,026	0,013	61	0,318	1,642	0,745	0,285	33	**<0,001***
Ho	35	ND				61	3,3E-05	0,001	1,7E-04	1,4E-04		
K	35	314,1	1310	963,0	248,4	61	1,422	743,5	47,33	108,4	33	**<0,001**
La	35	ND				61	0,001	0,020	0,004	0,004		
Li	35	2,3E-04	0,072	0,011	0,018	61	0,001	0,045	0,016	0,010	33	**<0,001**
Mg	35	20,28	71,80	52,90	13,06	61	10,12	155,35	77,77	32,19	33	**<0,001***
Mn	35	0,010	0,072	0,029	0,014	61	0,052	2,390	0,255	0,348	33	**<0,001**
Mo	35	0,007	0,026	0,016	0,005	61	0,029	0,256	0,101	0,047	33	**<0,001**
Na	35	2311	4908	2981	654	61	2,421	921,7	65,37	141,7	33	**<0,001**
Nd	35	8,4E-06	0,001	1,7E-04	1,8E-04	61	1,8E-04	0,019	0,004	0,004	33	**<0,001**
Ni	35	0,001	0,028	0,007	0,006	61	0,003	0,094	0,020	0,016	33	**<0,001**
P	35	187,5	1052	775,6	201,2	61	223,9	1267	496,0	159,3	33	**<0,001***
Pb	35	0,001	0,084	0,006	0,014	61	0,003	0,029	0,010	0,006	33	**<0,001**
Pr	35	ND				61	1,1E-04	0,005	0,001	0,001		
Rb	35	0,387	4,202	1,695	0,981	61	0,006	3,246	0,149	0,445	33	**<0,001**
S	35	1397	2615	1786	270,4	61	12576	25544	23643	1875	33	**<0,001**
Sb	35	ND				61	0,002	0,022	0,009	0,004		
Sc	35	ND				61	2,3E-04	0,027	0,003	0,004		
Se	35	0,185	0,917	0,462	0,173	61	0,483	2,056	1,414	0,344	33	**<0,001***
Si	35	1,500	15,88	5,829	3,047	61	6,356	192,56	36,15	33,38	33	**<0,001**
Sm	35	ND				61	1,5E-04	0,004	0,001	0,001		
Sn	35	1,1E-05	0,007	0,001	0,001	61	0,002	0,072	0,009	0,010	33	**<0,001**
Sr	35	0,021	0,054	0,029	0,006	61	0,027	0,190	0,072	0,031	33	**<0,001**
Tb	35	ND				61	3,3E-05	0,001	1,5E-04	1,3E-04		
Th	35	5,9E-06	3,3E-04	8,2E-05	8,3E-05	61	2,0E-04	0,030	0,002	0,004	33	**<0,001**
Ti	35	0,001	0,062	0,009	0,012	61	0,118	10,00	1,175	1,567	33	**<0,001**
Tl	35	6,4E-05	3,3E-04	1,4E-04	6,5E-05	61	1,8E-04	0,004	0,001	0,001	33	**<0,001**
U	35	1,4E-05	1,9E-04	5,4E-05	4,5E-05	61	7,4E-05	0,010	0,001	0,001	33	**<0,001**
V	35	3,5E-04	0,220	0,008	0,037	61	0,003	0,263	0,026	0,036	33	**<0,001**
W	35	ND				61	3,2E-04	0,014	0,003	0,003		
Y	35	3,1E-05	0,051	0,002	0,009	61	0,001	0,017	0,004	0,003	33	**<0,001**
Yb	35	ND				61	7,4E-05	0,002	4,3E-04	3,6E-04		
Zn	35	1,759	4,418	3,507	0,717	61	8,438	41,28	23,62	7,086	33	**<0,001***

For comparison of concentrations and profiles of elements in feathers and blood from nestlings, all feather and blood samples were included in the PCA. Figure 4 shows the loading plot and the score plot of component 1 and 2 from the multivariate analysis of nestlings feathers and blood. The two first components explain 67,4 % of the variation in Table 5. PC1 describes 52,1% of the variation and separates feathers and blood as described by the score plot in Figure 4b. PC2 describes 15,2%. The first two components are significant.

Table 5. Results of a Principal Component Analysis performed in Sigma 15 of nestling feathers and blood. The two first component are significant and explain 67,4% of variation.

Component	R2X	R2X(cum)	Eigenvalue	Q2	Limit	Q2(cum)	Significance	Iterations
0	Cent.							
1	0.521	0.521	26.6	0.492	0.0294	0.492	R1	7
2	0.152	0.674	7.77	0.255	0.0299	0.622	R1	15
3	0.0519	0.726	2.65	0.0184	0.0304	0.628	R2	69
4	0.0461	0.772	2.35	0.0445	0.0309	0.645	R1	34
5	0.0332	0.805	1.69	-0.0049	0.0315	0.643	R2	36

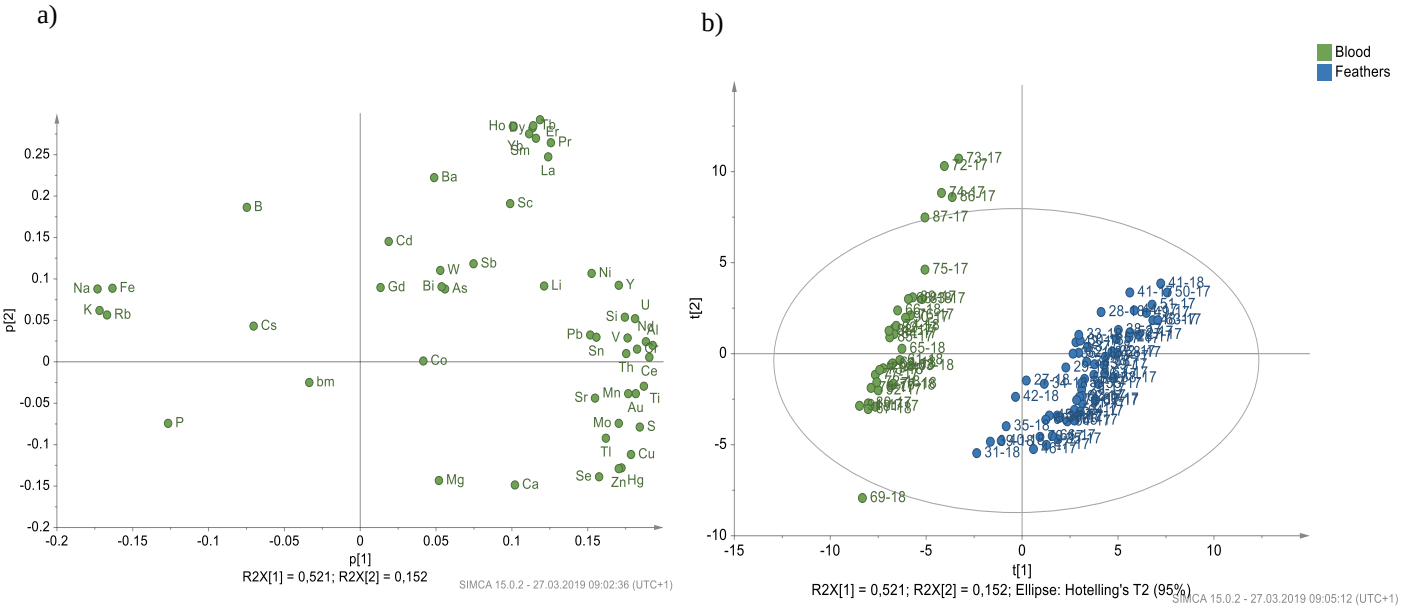

Figure 4. a) Loading plot and **b)** Score plot from the Principal Component Analysis of nestling feathers and blood. Hotelling's T2 ellipse (95%) with five outliers.

The loading plot in Figure 4a shows that some elements (e.g. Fe, Na, K and Rb) group together on the left side of the plot. Some other elements (e.g. B, P and Cs) are also on the left side of the loading plot, but they are more spread. These elements seem to have higher concentrations in blood, as blood samples also cluster on the left side of the score plot (Figure 4b).

Many of the elements cluster on the lower right side of the loading plot (e.g. Cu, Be, Hg, Se, Zn, S, Sr, Mo, Au and Mn) and some cluster in the central part of the right side of the loading

plot (e.g. Pb, Sn, Si, Ce, V and Th). Finally some elements cluster at the upper right part of the loading plot, that being some of the REE (e.g. La, Pr, Sm, Dy and Er). All the elements that cluster on the right side of the loading plot are more associated with feathers as feathers also cluster on the right side of the score plot (Figure 4b). REE are naturally on the left side here, as they were only detected in feathers, but included in the PCA to show the covariation among the rear earth elements in feathers of nestlings.

In the Pearson correlation analysis, individuals used in this analysis were limited to include the ones where both blood and feather samples of the nestlings were available (n=32). The results from the correlation analysis shows that there are significant positive correlations between blood and feathers of the nestlings (n=32) for 8 of the 36 elements (B, Hg, La, Mo, Rb, Se, Sr and U) (Table 6).

Table 6 shows the results from the Pearson correlation analysis for concentrations of 36 elements in blood and feathers of nestlings (n=32), significant correlations and p-values for the correlations are shown in bold.

		blood – feathers nestling	
Element	*n*	r	*p*
Al	32	0,142	0,437
As	32	0,108	0,558
Au	32	0,078	0,671
B	32	**0,429**	**0,014**
Ba	32	0,323	0,071
Ca	32	-0,249	0,169
Ce	32	0,272	0,132
Co	32	0,320	0,074
Cr	32	0,103	0,577
Cs	32	0,116	0,528
Cu	32	0,120	0,514
Fe	32	-0,291	0,106
Hg	32	**0,539**	**0,001**
K	32	0,212	0,245
La	32	**0,429**	**0,014**
Mg	32	-0,115	0,529
Mn	32	-0,067	0,714
Mo	32	**0,432**	**0,013**
Na	32	-0,117	0,523
Nd	32	0,348	0,051
Ni	32	0,152	0,406
P	32	0,096	0,602
Pb	32	0,199	0,274
Rb	32	**0,575**	**0,001**
S	32	0,155	0,396
Se	32	**0,458**	**0,008**
Si	32	0,010	0,956
Sn	32	0,333	0,063
Sr	32	**0,465**	**0,007**
Th	32	0,248	0,172
Ti	32	-0,186	0,308
Tl	32	0,016	0,931
U	32	**0,583**	**<0,0005**
V	32	-0,102	0,579
Y	32	0,109	0,554
Zn	32	-0,292	0,105

Some of the elements (Hg, Mo, Rb and Se) with significant correlations between blood and feather concentrations are shown in Figure 5.

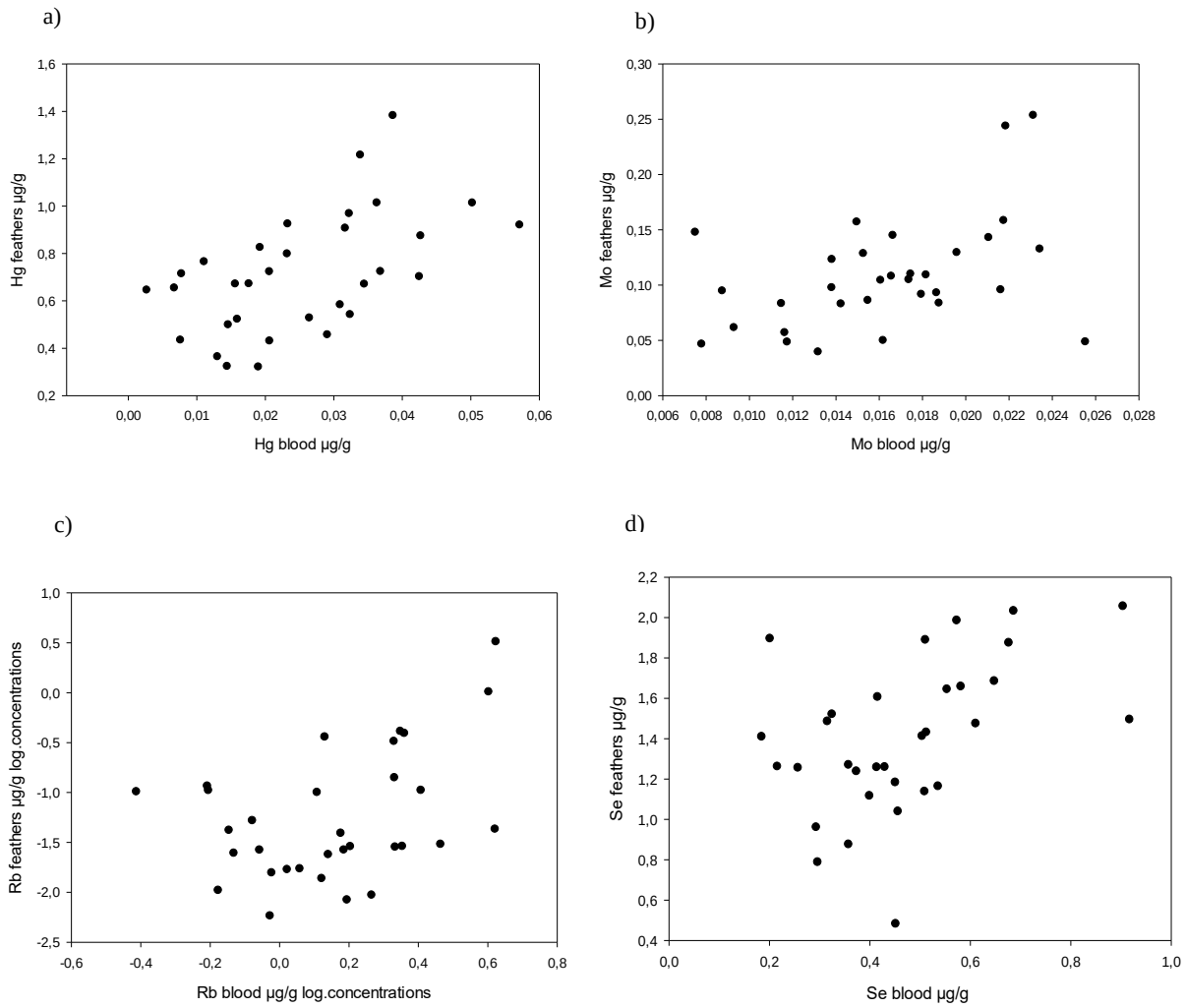

Figure 5 Scatter plots for selected elements in blood and feathers of nestling owls (n=32), **a)** shows the positive correlations for Hg (R^2= 0,29, p=0,001), **b)** shows the positive correlations for Mo (R^2=0,19, p=0,013) and **c)** shows the positive correlations for the log. concentrations of Rb (R^2=0,33, p=0,001), and **d)** shows positive correlations for Se (R^2= 0,213, p=0,008).

3.2 Comparison of elemental concentrations between adults and nestlings

A comparison of the concentrations in feathers of adults and feathers of nestlings (Table 1 and Table 4) showed that 42 elements (Ag, Al, As, Au, B, Ba, Bi, Cd, Ce, Co, Cr,Cs, Cu, Dy, Er, Fe, Ga, Hf, Hg, Ho, La, Lu, Mn, Mo, Ni, Nd, Pb, Pr, S, Sb, Sc, Si, Sm, Sr, Tb, Th, Ti, U, V, W, Y and Yb) were present in higher mean concentrations in feathers of the adults (n=72) compared with feathers of the nestlings (n=61), whereas 10 elements (Ca, K, Li, Mg, Na, P, Rb, Se, Tl and Zn) were present in higher values in the feathers of nestlings compared with the feathers of adults. Furthermore, a comparison of the concentrations in the blood of adults and the blood of nestlings (Table 1 and Table 4) showed that 22 elements (Al, Au, Ce, Cr, Cu, Fe, Gd, Hg, K,

Mn, Mo, Nd, Ni, P, Pb, Rb, S, Si, Th, Ti, U and W) were present in higher mean concentrations in the blood of adults (n=28) compared with the blood of nestlings (n=35). 17 of the elements (As, B, Ba, Cd, Ca, Co, Cs, Li, Mg, Na, Se, Sn, Sr, Tl, V, Y and Zn) were present in higher values in the blood of nestlings compared to the blood of adults.

3.2.1 Principal component analysis of feathers

For comparison of concentrations and profiles of elements in feathers of adults and nestlings together, all feathers samples were included in a Principal Component analysis. Figure 6a and Figure 6b show the loading plot and score plot from the multivariate analysis from component 1 and 2. The four first components in the PCA explain 66.6% of variation (Table 7). PC1 describes 44,6% of the variation and is separated in adults and nestlings as described in the score plot (Figure 6b). PC2, PC3 and PC4 describe 10,6%, 6,07% and 5,27%, respectively. All the first four components were significant.

Some elements (e.g. Hg, Pb, Cr, Ni and Cu) are clustered at the lower part on the right side of the loading plot (Figure 6a). They seem to be mostly connected to the adult feathers, as adult feathers also cluster at the same area of the loading plot according to the score plot (Figure 6b).

Some elements (e.g. Zn, Mg, Na, Ca, Tl, Rb, P) seem to be most connected to the nestling feathers, as they are grouping at the upper left part of the loading plot (Figure 6a), where also the nestling feathers are clustering according to the score plot (Figure 6b).

A PCA of concentrations and profiles of elements in feathers and blood of adults and nestlings combined are illustrated in Figure A2, Appendix.

Table 7. Principal Component Analysis performed on adult and nestling feathers. The four first component are significant and explain 66,6% of variation.

Component	R2X	R2X(cum)	Eigenvalue	Q2	Limit	Q2(cum)	Significance	Iterations
0	Cent.							
1	0.446	0.446	27.2	0.425	0.0235	0.425	R1	9
2	0.106	0.552	6.47	0.129	0.0238	0.499	R1	15
3	0.0607	0.613	3.7	0.0242	0.0242	0.512	R1	50
4	0.0527	0.666	3.22	0.0773	0.0245	0.549	R1	34

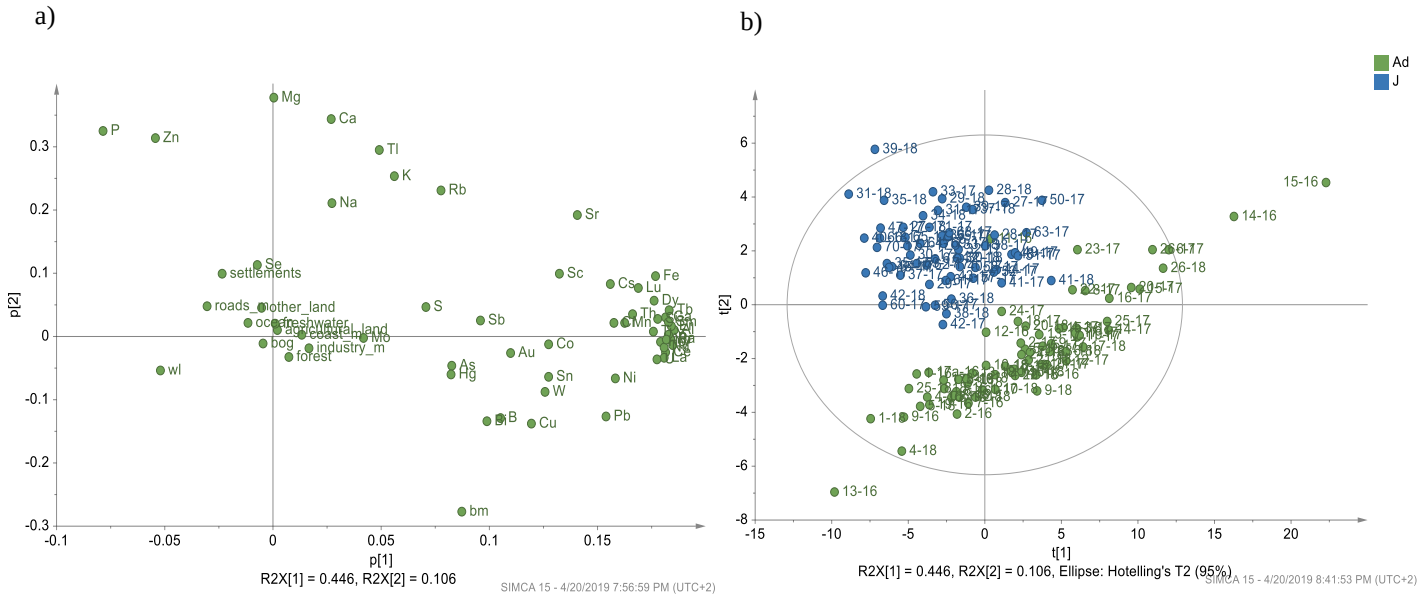

Figure 6. a) the loading plot and **b)** the score plot of component 1 and 2 from the Principal Component Analysis of adults and nestlings feathers. Hotelling's T2 ellipse (95%) with four outliers.

3.2.2 Principal component analysis of blood

For comparison of concentrations and profiles of elements in blood of adults and nestlings together, all blood samples were included in a Principal Component analysis. Figure 7 shows the loading plot in 7a and the score plot in 7b in the multivariate analysis from component 1 and 2 for adult and nestling blood. The five first components explain 66,1% of the total variation (Table 8). PC1 describes 29,6% of the variation and separates nestlings and adults by age as described by the score plot (Figure 7b). PC2, PC3, PC4, PC5 describe 13,9%, 8,87%, 7,85% and 5,85%, respectively. The first five components were significant.

Many elements seem to cluster on the upper part of the loading plot in Figure 7a (e.g. Hg, Rb, Zn, Pb and Cu) and seem to be most connected to the adult blood samples, which seem to cluster in the upper part of the score plot (Figure 7b). Other elements seem to be more connected to the

nestling blood samples (Sn, Tl, B, Co and Na), as they are found at the lower part of the loading plot in Figure 7a, where the nestling blood samples also appear to cluster in Figure 7b.

Table 8. Principal Component Analysis performed on adult and nestling blood. The five first components are significant and explain 66,1% of variation.

Component	R2X	R2X(cum)	Eigenvalue	Q2	Limit	Q2(cum)	Significance	Iterations
0	Cent.							
1	0.296	0.296	15.1	0.23	0.0348	0.23	R1	15
2	0.139	0.435	7.1	0.0832	0.0354	0.294	R1	28
3	0.0887	0.524	4.52	0.0467	0.0361	0.327	R1	78
4	0.0785	0.603	4	0.0471	0.0367	0.359	R1	28
5	0.0585	0.661	2.98	0.0433	0.0374	0.387	R1	46

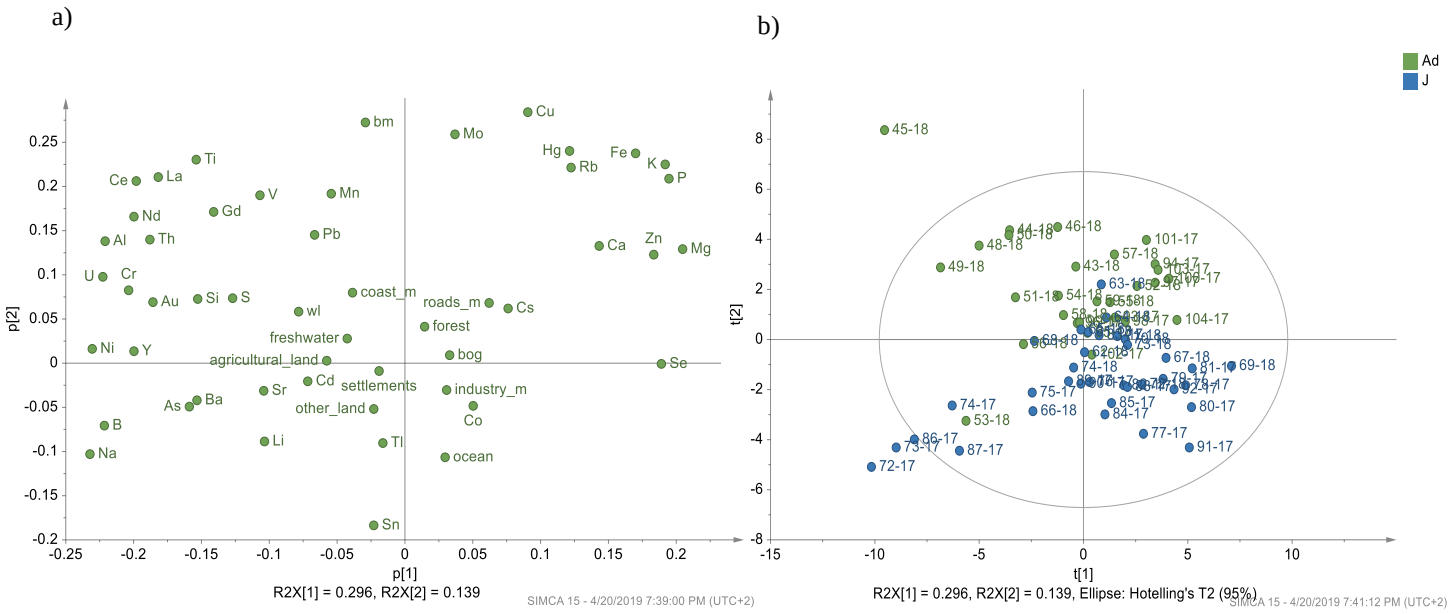

Figure 7. a) Loading plot and **b)** score plot of component 1 and 2 from the Principal Component Analysis of adult and nestling blood. Hotelling's T2 ellipse (95%) with four outliers.

3.2.3 Correlations analysis of blood and feathers combined

There were significant positive correlations between adult blood and nestling blood (n=19) in two of the 36 elements analyzed (Cd and Cs) (table 9). One element is shows negative correlations (Mo). In addition, there were significant positive correlations between adult feathers and nestling blood (n=29) for three of the 36 elements analyzed (Ba, Hg and Se). Furthermore, there were significant positive correlations in three of the 38 elements analyzed (As, Hg and Se) between adult blood and nestling feathers (n=19), and one of the 38 elements was negatively correlating (Au) (Table 9). In addition, there were significant positive correlations between adult feathers and nestling feathers (n=30) between 22 of the 47 analyzed elements (Al, As, Au, Ba, Ce, Co, Cr, Dy, Er, Fe, Hg, La, Mn, Nd, Pr, S, Sm, Sr, U, V, Y and

Yb). Six of the significant correlations (Cs, Hg, As, Hg, As and Hg) from Table 9, are shown in Figure 8.

Table 9. Results from the Pearson correlation analysis for concentrations of 36 elements in adult blood vs. nestling blood (n=19), for concentration of 36 elements in adult feathers vs. nestling blood (n=29), for concentrations of 38 elements in adult blood vs. nestling feathers (n=19), and for concentration of 47 elements in adult feathers vs. nestling feathers (n=30). Significant correlations and *p*-values for the correlations are bold. ND=<50%LOD.

	adult blood – nestling blood			**adult feathers – nestling blood**			**adult blood – nestling feathers**			**adult feathers – nestling feathers**		
	n	r	*p*	*n*	r	*p*	*n*	r	*p*	*n*	r	*P*
Al	19	-0,040	0,870	29	0,156	0,418	19	-0,096	0,695	30	**0,543**	**<0,002**
As	19	0,356	0,135	29	-0,037	0,847	19	**0,632**	**<0,004**	30	**0,693**	**<0,0001**
Au	19	-0,319	0,183	29	0,355	0,059	19	**-0,530**	**<0,02**	30	**0,375**	**<0,05**
B	19	-0,150	0,539	29	-0,181	0,346	19	-0,261	0,280	30	-0,061	0,751
Ba	19	-0,294	0,222	29	**0,377**	**<0,05**	19	-0,438	0,061	30	**0,401**	**<0,03**
Bi	19	ND	ND	29	ND	ND	19	ND	ND	30	-0,067	0,727
Ca	19	0,024	0,923	29	0,224	0,244	19	0,081	0,741	30	0,267	0,154
Cd	19	**0,542**	**<0,02**	29	-0,038	0,845	19	ND	ND	30	ND	ND
Ce	19	0,127	0,604	29	0,194	0,314	19	-0,030	0,904	30	**0,546**	**<0,002**
Co	19	0,083	0,737	29	0,250	0,191	19	0,287	0,234	30	**0,786**	**<0,000001**
Cr	19	-0,020	0,936	29	0,070	0,719	19	-0,140	0,567	30	**0,386**	**<0,04**
Cs	19	**0,865**	**<0,00001**	29	-0,040	0,838	19	0,205	0,400	30	0,057	0,765
Cu	19	-0,203	0,404	29	0,149	0,442	19	-0,220	0,365	30	0,260	0,165
Dy	19	ND	ND	29	ND	ND	19	ND	ND	30	**0,374**	**<0,05**
Er	19	ND	ND	29	ND	ND	19	ND	ND	30	**0,422**	**<0,03**
Fe	19	-0,037	0,882	29	-0,235	0,220	19	-0,144	0,555	30	**0,590**	**<0,0006**
Hg	19	0,179	0,463	29	**0,451**	**<0,02**	19	**0,704**	**<0,001**	30	**0,666**	**<0,00006**
Ho	19	ND	ND	29	ND	ND	19	ND	ND	30	0,316	0,089
K	19	-0,151	0,538	29	**-0,331**	**<0,08**	19	-0,286	0,235	30	-0,071	0,709
La	19	ND	ND	29	ND	ND	19	-0,038	0,877	30	**0,618**	**<0,0003**
Li	19	0,230	0,344	29	ND	ND	19	0,152	0,534	30	ND	ND
Mg	19	0,058	0,814	29	0,005	0,980	19	0,450	0,053	30	0,198	0,295
Mn	19	0,040	0,871	29	0,082	0,672	19	-0,235	0,333	30	**0,372**	**<0,05**
Mo	19	**-0,469**	**<0,05**	29	-0,021	0,916	19	-0,241	0,320	30	-0,209	0,267
Na	19	-0,148	0,545	29	0,314	0,098	19	0,453	0,051	30	0,011	0,955
Nd	19	-0,040	0,870	29	0,354	0,060	19	-0,020	0,935	30	**0,645**	**<0,0002**
Ni	19	-0,179	0,462	29	-0,036	0,852	19	-0,063	0,799	30	0,301	0,106
P	19	-0,018	0,942	29	-0,045	0,819	19	0,074	0,763	30	0,193	0,307
Pb	19	-0,011	0,966	29	-0,024	0,902	19	0,088	0,721	30	0,020	0,917
Pr	19	ND	ND	29	ND	ND	19	ND	ND	30	**0,576**	**<0,001**
Rb	19	0,126	0,608	29	-0,122	0,527	19	0,353	0,139	30	0,025	0,896
S	19	-0,054	0,826	29	0,254	0,184	19	0,128	0,602	30	**0,562**	**<0,002**
Sb	19	ND	ND	29	ND	ND	19	ND	ND	30	0,301	0,106
Sc	19	ND	ND	29	ND	ND	19	ND	ND	30	0,137	0,471
Se	19	0,276	0,253	29	**0,387**	**<0,04**	19	**0,564**	**<0,02**	30	0,292	0,117
Si	19	-0,049	0,843	29	0,158	0,412	19	0,048	0,846	30	0,198	0,293
Sm	19	ND	ND	29	ND	ND	19	-0,172	0,482	30	**0,564**	**<0,002**
Sn	19	ND	ND	29	0,091	0,638	19	ND	ND	30	-0,004	0,984
Sr	19	0,063	0,799	29	-0,056	0,772	19	-0,133	0,586	30	**0,365**	**<0,05**
Tb	19	ND	ND	29	ND	ND	19	ND	ND	30	0,252	0,180
Th	19	0,176	0,470	29	-0,275	0,148	19	0,074	0,765	30	-0,098	0,608
Ti	19	0,039	0,874	29	-0,224	0,244	19	-0,125	0,609	30	0,299	0,108
Tl	19	0,028	0,909	29	-0,103	0,594	19	0,150	0,541	30	0,105	0,580
U	19	-0,051	0,837	29	0,317	0,094	19	-0,099	0,688	30	**0,595**	**<0,001**
V	19	-0,010	0,967	29	-0,111	0,565	19	-0,297	0,217	30	**0,585**	**<0,0007**
W	19	ND	ND	29	ND	ND	19	-0,111	0,652	30	0,094	0,621
Y	19	-0,137	0,576	29	0,030	0,878	19	-0,139	0,570	30	**0,574**	**<0,001**
Yb	19	ND	ND	29	ND	ND	19	ND	ND	30	**0,440**	**<0,02**
Zn	19	-0,110	0,654	29	-0,109	0,574	19	0,400	0,089	30	0,115	0,544

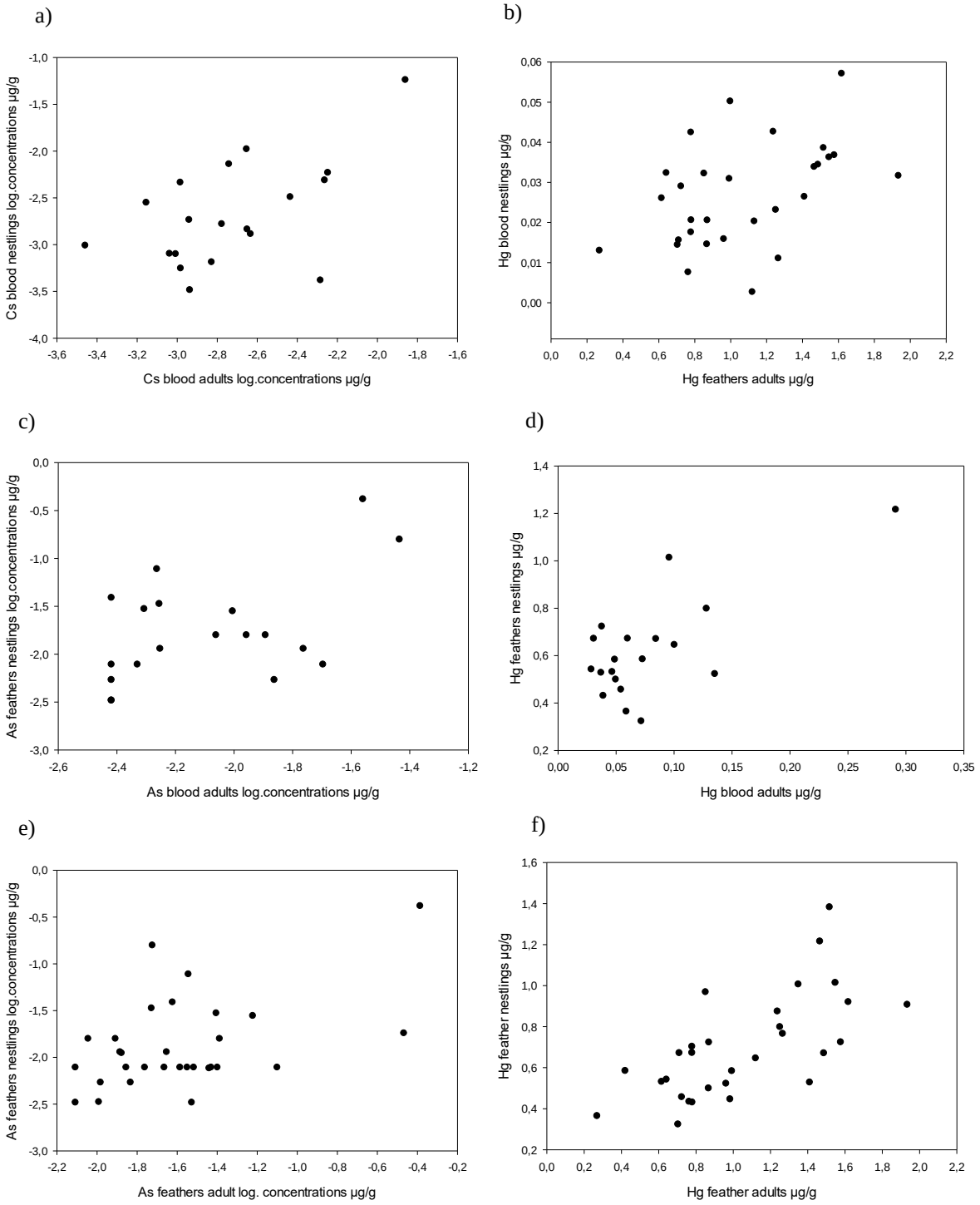

Figure 8. Scatter plots of the correlations for selected elements in the comparison of adults and nestlings. **a)** The positive correlations of the log. concentrations of Cs in adult blood vs. nestling blood (R^2= 0,75, p=0,00001), **b)** the positive correlations of Hg in adult feathers vs. nestling blood (R^2=0,20, p<0,02), **c)** the positive correlations for the log. concentrations of As in adult blood vs. nestling feathers (R^2=0,40, p<0,004), **d)** the positive correlations for Hg in adult blood vs. nestling feathers (R^2=0,5, p=<0,001**) e)** the positive correlation for the log. concentrations of As in adult feathers vs. nestling feathers (R^2= 0,48, p<0,0001) and **f)** the positive correlations for Hg in adult feathers vs nestling feathers (R^2= 0,44, p<0,00006**)**,

3.3 Analysis of habitat variations and annual variations

3.3.1 PCA of elements in blood versus land use, sampling year and municipality

The three first components of the PCA explained 60,3% of the total variation (Table 10). PC1 described 32,8% of the variation, PC2 and PC3 described 17,1% and 10,5%, respectively. The first and the third component were significant. Several of the elements (e.g. As, B, Ba, Cr and Mn) cluster at the left part of the loading plot in Figure 9a, and in the score plot in Figure 9b it appears that many of the samples from 2018 cluster at the same place. It also seemed like ocean and freshwater lakes in figure 9a were more represented where these elements cluster. From the score plot in Figure 9c these samples seemed to be spread in all the different municipalities. At the upper right part of the loading plot in Figure 9a, some of the elements (e.g. Cu, Cs, Hg, Zn and Rb) seemed to dominate, and these elements covaried with samples from both sampling years 2017 and 2018 in Figure 9b. From the score plot in Figure 9c) most of these samples seemed to be spread in all the municipalities. Three out of four samples from Steinkjer were clustered here. In addition, it seemed like forest and bog weakly covaried with the same area in the loading plot in Figure 9a. Distance to road and distance to industry both cluster at the same place, and that could indicate that the concentrations of the elements clustered at the same place in the loading plot seemed to increase the longer the distance to road or distance to industry were (as distance was measured in meters).

On the lower right part on the loading plot, three elements (Cd, Pb and Mg) seemed to covary with mainly samples of 2017. Here it seemed that samples from the municipalities of Levanger and Verdal were the only samples represented (Figure 9c). According to the loading plot in figure 9a, the elements seemed to covary with the landscape type other-land and distance to coast, which means in this case that the elemental concentration of these elements will increase with increasing distance to the sea.

Table 10. Results from the multivariate analysis using PCA of 40 elements, bm=body mass and wl=wing length, in adults blood together with different types of land use (forest, settlements, agricultural land, freshwater lakes, other land and oceans) and distance to pollution sources (distance to roads, industry and oceans). The three first components explain 60,3% of the variation. The first and third components are significant.

Component	R2X	R2X(cum)	Eigenvalue	Q2	Limit	Q2(cum)	Significance	Iterations
0	Cent.							
1	0.328	0.328	9.17	0.222	0.0539	0.222	R1	17
2	0.171	0.498	4.78	-0.0145	0.0556	0.211	R2	26
3	0.105	0.603	2.93	0.0727	0.0573	0.268	R1	27
4	0.0655	0.668	1.83	-0.0255	0.0592	0.249	R2	42
5	0.0546	0.723	1.53	-0.0109	0.0612	0.241	R2	27

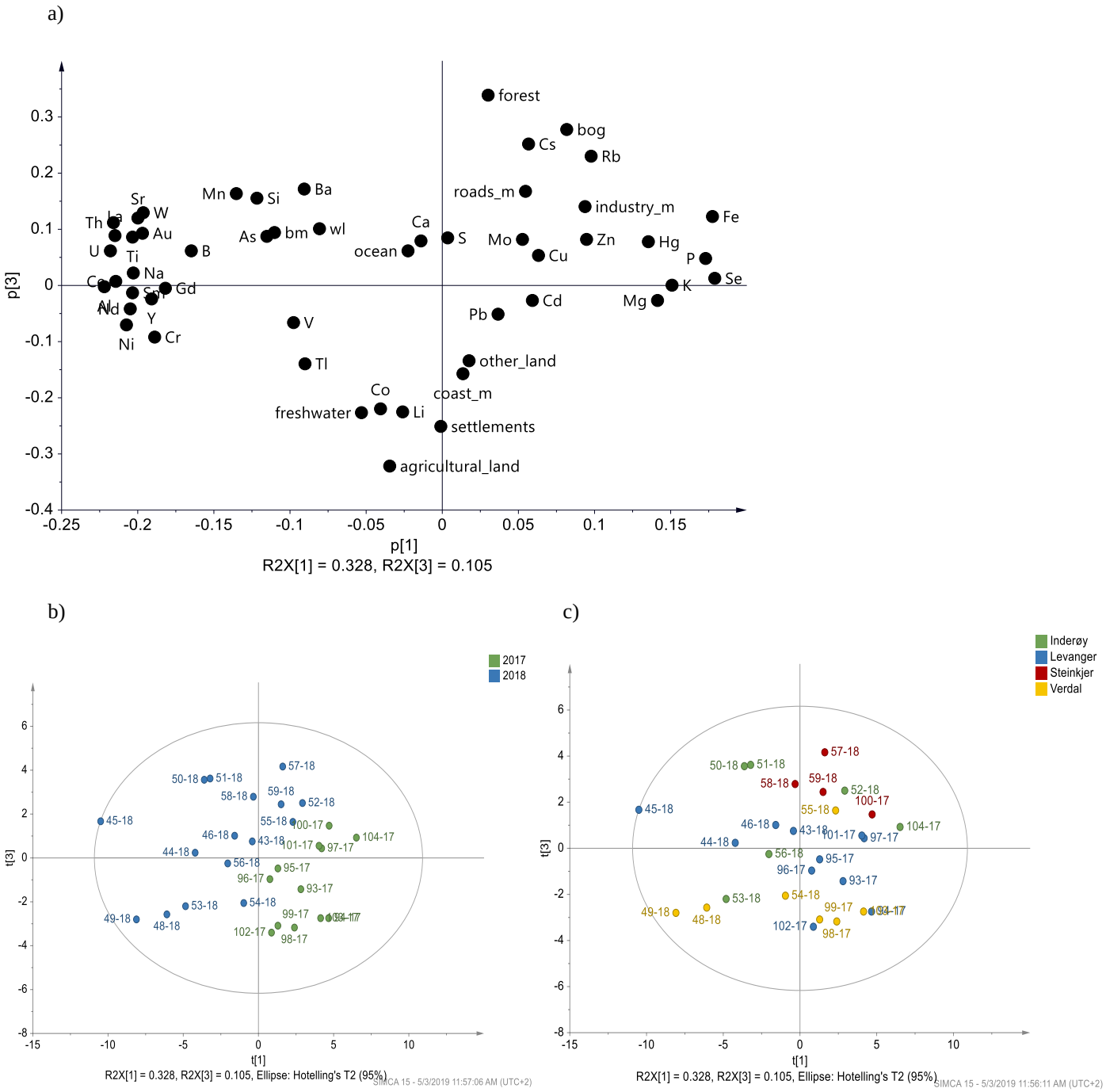

Figure 9. Component 1 and 3 in **a)** a loading plot of adults blood with bm=body mass and wl=wing length and GIS data of the habitats included (forest, settlements, agricultural land, freshwater lakes, other-land and oceans), together with distance to pollution sources (distance to roads, industry and oceans), **b)** a score plot of adults blood organized in the two different sampling years, and **c)** a score plot of adults blood organized in 4 different municipalities. Score plots with Ellipse Hotelling's T2 (95%) and no outliers.

A principal component analysis of the blood of the nestlings in relation to the land use can be found in Figure A3, Appendix.

3.3.2 PCA of elements in feathers versus land use, sampling year and municipality

The two first components in the PCA explain 69,1% of the total variation (Table 11). PC1 and PC 2 describe 51,7% and 7,41% of the variation, respectively, and they are both significant.

Several elements (e.g. Cr, Cs, Mn, Ni and many of the REE) clustered at the outmost right part of the loading plot in Figure 10a, and according to the score plot in figure 10b it seemed like most of these elements were mainly associated with samples from the sampling years of 2017 and 2018. It was difficult to identify any associating patterns between these elements and the municipalities in Figure 10c. According to the loading plot in figure 10a, there was no obvious connection between the samples on the outmost right side and the different land use in feathers. Some of the elements were more spread at the right side of the loading plot in figure 10a (e.g. Cu, Co, Hg, Mo, Pb, Sb and Zn). According to figure 10b, it seemed like most of these samples are connected to the sampling year of 2017 with a few samples from 2018. In Figure 10c, these samples seemed to be spread in all the municipalities. None of the spread samples on the right side of the loading plot seemed to be connected to any of the different land uses, except for Mo which seems to be associated with sea. At the left side of the loading plot in figure 10a there are no elements. Most of the samples from 2016 are spread here (Figure 10b), and the municipalities of Verran and Verdal were mainly represented here (Figure 10c). Wing length (wl) and body mass (bm) seemed to be more associated with these samples in the loading plot. In particular, wing length but also body mass seemed to be negatively associated with many of the rare earth elements in the loading plot, Figure 10a.

Table 11. Principal Component Analysis performed on adult feathers. The two first components are significant and explain 59,1% of the variation.

Component	R2X	R2X(cum)	Eigenvalue	Q2	Limit	Q2(cum)	Significance	Iterations
0	Cent.							
1	0.517	0.517	33.1	0.487	0.0291	0.487	R1	8
2	0.0741	0.591	4.74	0.0549	0.0295	0.515	R1	40
3	0.055	0.646	3.52	0.0217	0.0299	0.526	R2	60
4	0.0461	0.692	2.95	-0.00172	0.0304	0.525	R2	36

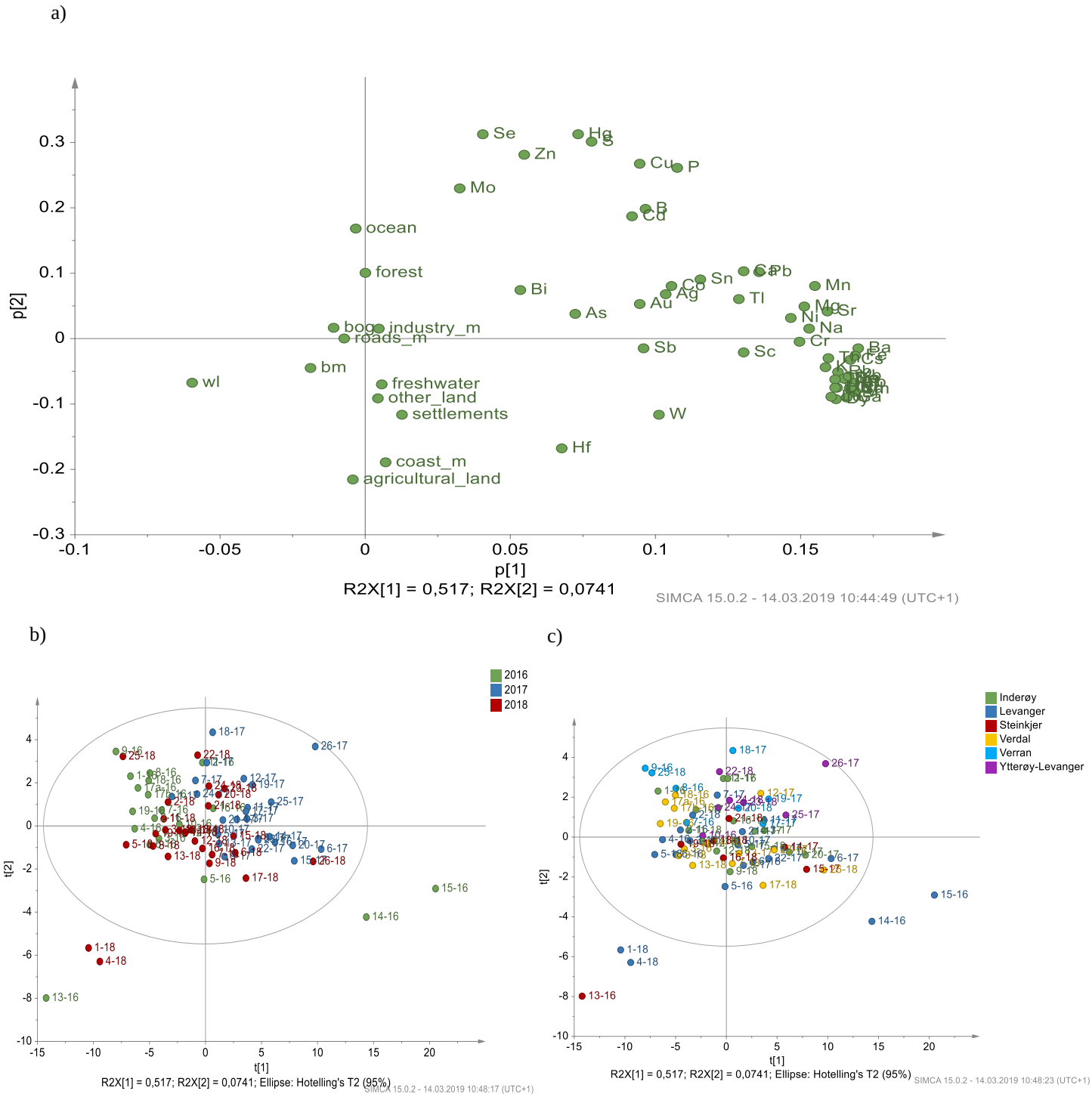

Figure 10. Component 1 and 2 in **a)** a loading plot of adults feathers with bm=body mass and wl=wing length and GIS data of the habitats included (forest, settlements, agricultural land, freshwater lakes, other-land and oceans), together with distance to pollution sources (distance to roads, industry and oceans), **b)** a score plot of adults feathers organized in the three different sampling years, and **c)** a score plot of adults feathers organized in 6 different municipalities/ areas. Score plots with Ellipse Hotelling's T2 (95%) and five outliers.

A principal component analysis of the feathers of the nestlings, and adult and nestling feathers, in relations to the land use could be found in Figure A4 and Figure A5, Appendix, respectively.

3.3.3 Correlations between elements in tawny owls and land use

Table 12. A selection of toxicologically interesting correlations of elements from adult blood, adult feathers, nestling blood and nestling feathers in relation to the GIS parameters, settlements, agricultural land, freshwater lakes, forest, distance to roads and distance to industry.

GIS parameters	Adults blood				Adults feathers				Nestlings blood				Nestlings feathers			
		n	r	p		n	r	p		n	r	p		n	r	p
Settlements	**Fe**	28	0,46	<0,02	**B**	72	0,33	<0,005	no correlations				**Zn**	61	0,27	<0,04
	Mg	28	0,41	<0,03	**Bi**	72	0,26	<0,03					**Sb**	61	0,28	<0,035
Agriculture land	**Co**	28	0,59	<0,001	**Sb**	72	0,29	<0,015	no correlations				**Sb**	61	0,44	<0,0005
	Li	28	0,38	<0,05												
Freshwater lakes	**Hg**	28	0,62	<0,001	**Al**	72	0,24	<0,045	**Y**	35	0,65	<0,0001	**Au**	61	0,28	<0,03
	Pb	28	0,58	<0,002	**Co**	72	0,40	<0,001					**Hg**	61	0,29	<0,03
Forest	**Rb**	28	0,43	<0,03	**Hg**	72	0,30	<0,015	**Cs**	35	0,44	<0,01	**Cs**	61	0,30	<0,03
									Rb	35	0,50	<0,01				
Distance - roads	no correlations				no correlations				no int. correlations				no int. correlations			
Distance - industry	**Hg**	28	0,51	<0,007	no correlations				**Sr**	35	-0,35	<0,04	**Hg**	61	0,35	<0,006

3.3.3.1 Settlements

In the correlation analysis of elemental concentrations in tawny owls and the area of settlements within their habitats, there were significant positive correlations for four elements in the blood (n=28) of adults (Fe, K, Mg, P) and no correlations for elements in the blood (n=35) of nestlings (Table A6 and Table A7, Appendix).

There were significant positive correlations for three elements in adult feathers (n=72) (B, Bi, Ca) and significant positive correlations for five elements in nestling feathers (n=61) (Ca, Mg, Sb, W, Zn). In addition there was a significant negative correlation for one elements in nestling feathers (Hg). Some of the most interesting elements that were correlated with the area of settlements are summarized in Table 12 (Fe, Mg, B, Bi, Zn, Sb). Scatter plots were made for Fe in adult blood and Zn in nestling feathers (Figure 11).

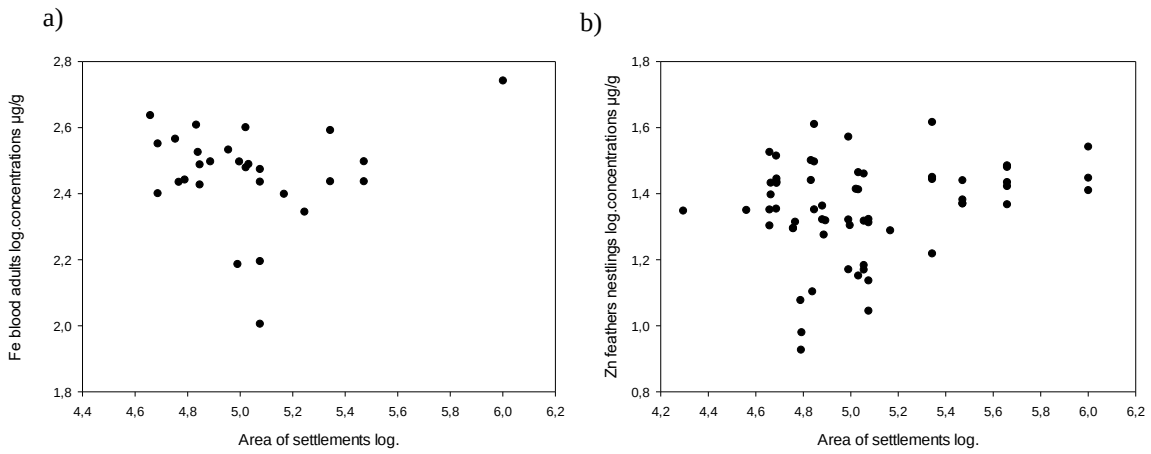

Figure 11. **a)** The log.concentration of Fe in adult blood (R^2= 0,21, p=0,015) and **b)** the log. concentration of Zn in nestling feathers (R^2=0,07, p=0,04) in relation to the log.values of the area of settlements within their territory.

3.3.3.2 Agricultural land

In the correlation analysis of elemental concentrations in tawny owls and the area of agricultural land within their habitats, there were significant positive correlations for two elements in adult blood (Co, Li), and significant negative correlations for three element in adult blood (Ba, Cs, Rb) (n=28). There were significant negative correlations for two elements in nestling blood (Cs, Rb) (n=35) (Table A8 and Table A9, Appendix).

In addition, there was a significant positive correlation for one element in adult feathers (Sb) (n=72) and significant negative correlations for two elements in adults feathers (Hg, Se). Furthermore, there were significant positive correlations for four elements in nestling feathers (Li, Nd, Pr, Sb) (n=61), and significant negative correlations for three elements in nestling feathers (Hg, Mn, Tl). Some of the most interesting elements that correlated with the area of agricultural land are summarized in Table 12 (Co, Li, Sb). Scatter plots were made for the correlations of Co and Li from adult blood and Sb from adult feathers, and for Sb from nestling feathers (Figure 12).

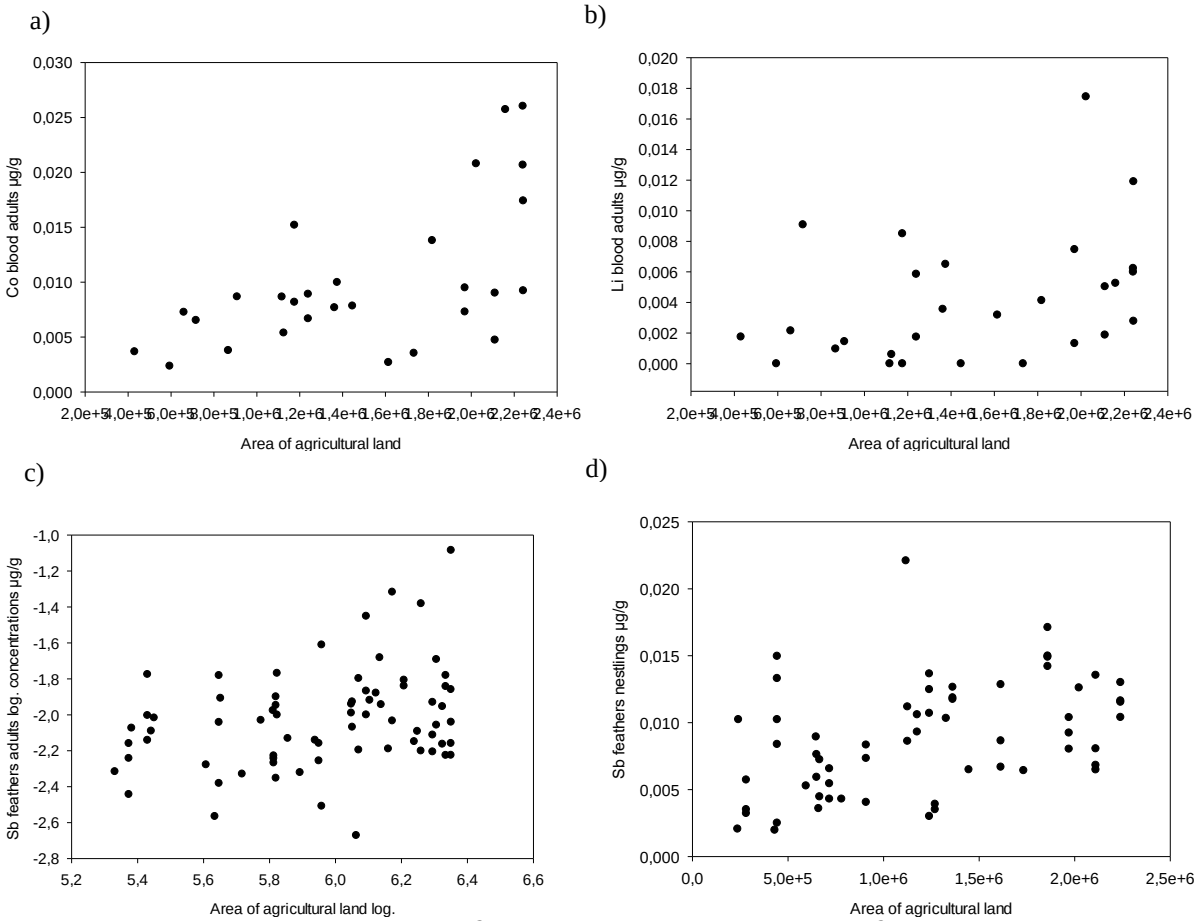

Figure 12. Scatter plots of **a)** Co (R^2= 0,35, p=0,001) and **b)** Li (R^2= 0,15, p=0,045) in adult blood, **c)** Sb (R^2= 0,09, p=0,013) in adult feathers and **d)** Sb (R^2= 0,19, p<0,0005) in nestling feathers in relation to area of agricultural land within their territory.

3.3.3.3 Forest

In the correlation analysis of elemental concentrations in tawny owls and the area of forest within their habitats, there was a significant positive correlation for one element in adult blood (Rb) (n=28), and a significant negative correlation for one element in adult blood (Co). There were significant positive correlations for five elements in nestling blood (Ce, Cs, Gd, Rb, Ti) (n=35) (table A10 and A11, Appendix).

There was a significant positive correlation for one element in adult feathers (Hg) (n=72) and significant negative correlation for one element in adult feathers (Sb). There was a significant positive correlation for one element in nestling feathers (Cs) (n=61).

Some of the most interesting elements that correlated with area of forest are summarized in Table 12 (Rb, Hg, Cs). Scatter plots were made for the correlations of Rb in adult blood and nestling blood, Hg in adult feathers and Cs for nestling feathers (Figure 13).

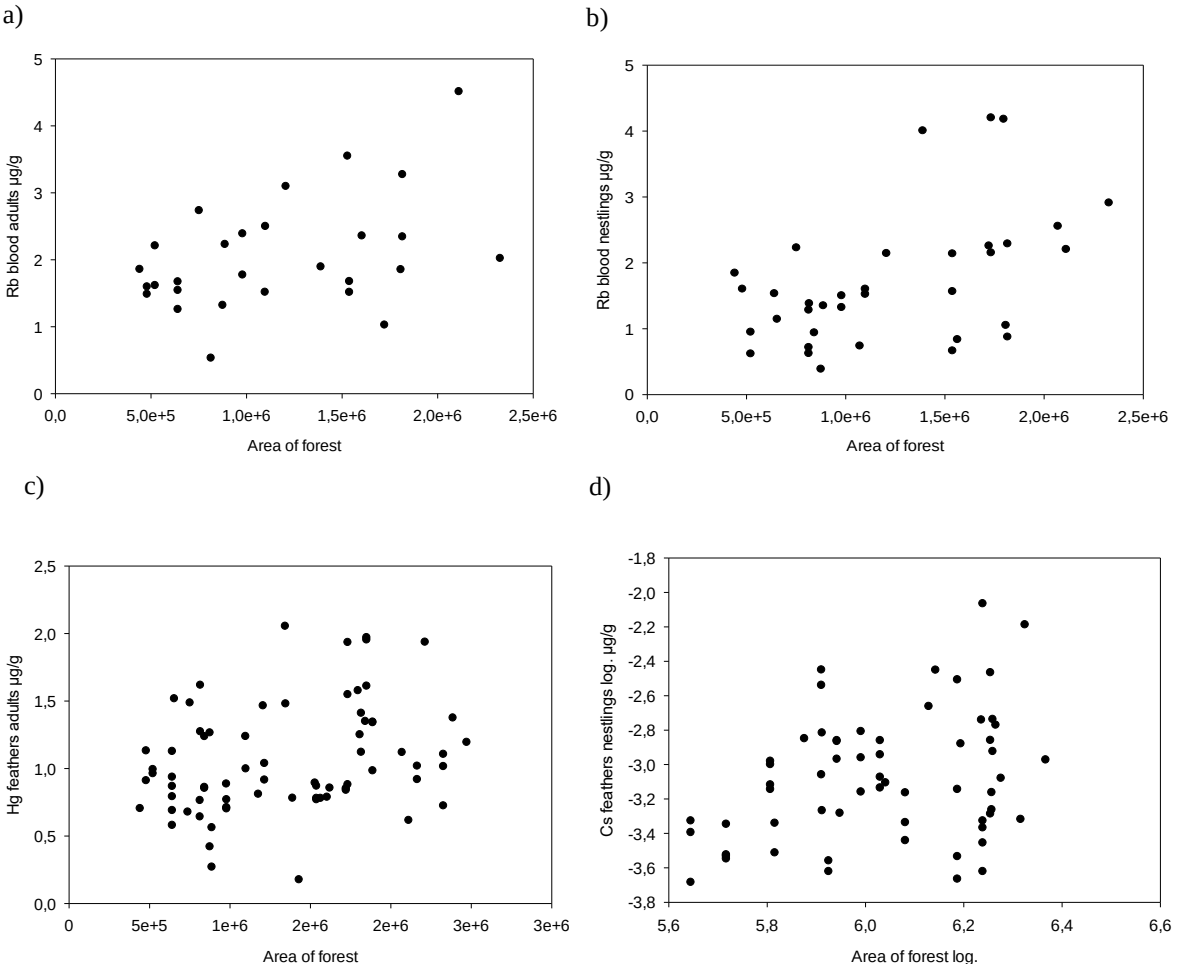

Figure 13. a) Rb (R^2= 0,18, p=0,02) in adults blood, **b)** Rb (R^2= 0,25, p<0,01) in nestlings blood, **c)** Hg (R^2= 0,09, p=0,01) in adult feathers and **d)** Cs (R^2= 0,19, p<0,01) in nestlings feathers in relation to area of forest within their territory.

3.3.3.4 Freshwater lakes

In the correlation analysis of elemental concentrations in owls and the area of freshwater within their habitats, there were significant positive correlations for three elements in adult blood (Hg, Pb, V) (Table A12, and Table A13, Appendix). Furthermore, there was a significant positive correlation for one element in nestling blood (Y).

There were significant positive correlations for 23 elements in adult feathers (Al, Co, Dy, Er, Fe, Ga, Hf, Ho, La, Lu, Nd, Pr, Sc, Si, Sm, Sr, Tb, Th, Ti, U, V, Y, Yb). There were positive significant correlations for three elements in nestling feathers (Au, Hg, Tl), and negative significant correlations for two elements in nestling feathers (Li, S).

Some of the most interesting elements that were correlated with the area of freshwater are summarized in Table 12 (Hg, Pb, Al, Co, Y, Au).

3.3.3.5 Distance to roads

In the correlation analysis of elemental concentrations in owls and the distance to roads from the nest boxes, there were no significant correlations for any of the tested elements in blood of the adults. There were positive significant correlations for two elements in nestling blood (Mo, Sr) (Table A14 and A15, Appendix).

There were no correlations between distance to roads and concentrations of elements in feathers of the adults. There were significant positive correlation for six elements (Ca, Hg, Mg, Mn, Sr, Tl), and negative significant correlations in four elements (Er, Ho, Y, Yb) in feather of the nestlings.

3.3.3.6 Distance to industry

In the correlation analysis of elemental concentrations in owls and the distance to industry from the nest boxes, there was a significant positive correlation for one element in adult blood (Hg) (Table A16 and Table A17, Appendix). There was a significant negative correlation for one element in nestling blood (Sr).

There were no correlations between distance to industry and concentrations of elements in feather of the adults. There were significant positive correlations for four elements (Au, Bi, Hg, Ti) in feathers of the nestlings.

Some of the most interesting elements that were correlated with the area of freshwater are summarized in Table 12 (Hg, Sr). Scatter plots were made for the correlations of Hg in adult blood, and Sr in nestling blood (Figure 16).

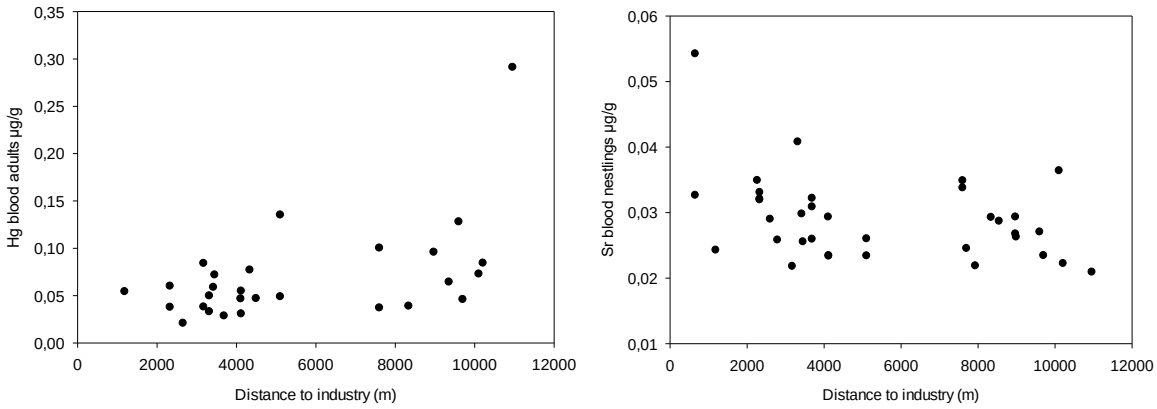

Figure 16. a) Hg (R^2= 0,26, *p*=0,006) in adults blood and **b)** Sr (R^2= 0,13, *p*=0,037) in nestlings bloods in relation to the distance to industry (in m) measured from the nest boxes.

4 Discussion

4.1 Comparison of elements in feathers and blood

4.1.1 Adults

This study shows the presence of a wide variety of elements in adult tawny owls living in proximity to the Trondheimsfjord in Central Norway. The screening of the elements in blood and feathers of the adult owls revealed that several elements were present at significantly higher mean concentrations in feathers compared with blood (Table 1). This includes some of the major toxic elements, e.g. As, Cd, Cr, Hg, Ni, Pb, some of the essential metals with potential toxicity, e.g. Co, Cu, Mn, Mo, Se (non-metallic), Zn, and a few of the minor toxic elements e.g. Al, Au, Ba, Cs, Tl, Ti, U and V. In addition, some of the minor toxic elements Sb, Ag and Sn were only detected in feathers as the levels in blood were not detectable. This was also the case with Bi and Ga which can be toxic under certain condition (Casarett & Doull, 2013).

Several routes contribute to the accumulation of pollutants in feathers. First, there is an internal distribution and uptake of pollutants in feathers, as birds have the possibility to transport some metals into growing feathers, and a relatively high amount of certain elements (e.g. Hg, As and Zn) are therefore stored in feathers (Barbieri *et al.*, 2010; Borghesi *et al.*, 2016; Jaspers *et al.*, 2004). In this way birds are able to excrete a substantial level of certain elements through feathers during moulting (Burger, 1993). Since high concentrations of Hg are deposited into feathers and have shown a remarkably stability, feathers are very suitable biomonitors for Hg contamination (Jaspers *et al.*, 2004). According to the study of Dauwe *et al.* (2003), the levels of Hg in feathers accurately reflects Hg levels in the blood when the feathers were formed. This suggests that feathers are not, or only slightly, affected by external contamination. Still, other issues may affect variation of Hg in feathers. Variability in Hg concentrations within and among individual feathers from the same bird combined with differences in feather collection methods can limit a study's interpretability (Peterson *et al.*, 2019). Lower variability of Hg concentrations among individual whole body feathers makes body feathers preferable to wing and tail feathers for most Hg studies in birds (Peterson *et al.*, 2019). To limit potential variability, this was taken into account in this study and body feathers were collected for adults. The mean concentrations of Hg from adult owls were 0,069 µg/g for blood and 1,054 µg/g for feathers. In a study performed by Evers *et al.* (2008), using the common loon (*Gavia immer*) as an upper trophic level bioindicator of aquatic Hg toxicity in freshwater lakes, multiple endpoints (behavior, physiology, survival and reproductive success) established adverse effect thresholds

for adult loons at 3,0 µg/g in blood and 40,0 µg/g in feathers. Espin *et al.* (2014) showed that Hg concentrations in blood of Griffon vultures (*Gyps fulvus*) higher than 0,03 µg/g increased oxidative stress biomarkers (induction of 10% in SOD activity). In that case the mean concentrations of Hg in adult Tawny owls exceed the toxicity threshold of Hg. In the same study of Espin *et al.* (2014), Cd concentrations in blood of Griffon vultures greater than 0,0005 µg/g produced effects on oxidative stress biomarkers. The mean concentrations for Cd in this study were 0,002 µg/g for feathers and 0,0006 µg/g for blood of the adults. Compared to the blood levels of Griffon vultures, the toxicity threshold for Cd were exceeded by adult tawny owls in our study area.

The other routes that can contribute to the level of pollutants in feathers are the external contamination that can originate from direct atmospheric deposition (wet or dry), and from elements secreted by the uropygial gland and applied to feathers during preening. Finally, uptake in feathers can originate from dust and sediments as demonstrated in the experiments of Borghesi *et al.* (2016); Cardiel *et al.* (2011); Dauwe *et al.* (2003) and Jaspers *et al.* (2004). Borghesi *et al.* (2016) demonstrated in an experiment analyzing feathers of wild Greater Flamingos (*Phoenicopterus roseus*), that the concentrations of several of the elements found in higher levels in feathers compared to blood, like many of the elements found in this study, are believed to be the result of external contamination. Higher feather concentrations of elements such as Al, Ce, Co, La, Li, Mn, Nd, Pb, Sm, Th, Ti, V and Y, were demonstrated by the experiment of Borghesi *et al.* (2016) to result from external contamination as it is difficult to clean feathers properly. In particular Al was mentioned in the study of Borghesi *et al.* (2016), since it is a metal with very low intestinal absorption rates yet found in an overall mean of 154 µg/g in the flamingo feathers. The metal was found very abundant in sediments, up to 18700±1992 µg/g, and these high burdens suggest that it is difficult to remove clay by using the washing procedures suggested in literature (Borghesi *et al.*, 2016). Borghesi *et al.* (2016) suggested that Al can be considered one of the key elements for checking external contamination in feather studies. In the present study, the mean concentrations of Al in adult feathers were found to be 45,27µg/g±117,79, which in this case most likely represents the external contamination of Al on adult tawny owl feathers in the study area. Elements that were only detected in feathers and not in blood in the present study, such as Dy, Er, Ga, Hf, Ho, Lu, Pr and Tb, were also classified as resulting from external contamination as Borghesi *et al.* (2016) indicated that REEs found in feathers were derived from soil particles captured by the feathers. In the study of Dauwe *et al.* (2003) there were strong indications that external

contamination had an important impact on the levels detected of elements such as Al, Co, Ni, Pb, Zn in the feathers of different birds of prey such as tawny owls. These elements were found in higher values in feathers compared to blood in the present study as well. In the study of Jaspers *et al.* (2004), the relative importance of external contamination of heavy metals onto feathers of free-living great tits (*Parus major*) was demonstrated, and that contamination differed among elements. The results from that study revealed that for elements such as Ag, Al, As, Cd, Co, Cu, Fe, Pb, Mn and Tl, external deposition onto the feathers was an important route of contamination.

The tendency of certain elements to covary with sample type (feathers vs. blood) could also be observed in the multivariate analysis of feathers and blood for adults (Figure 2). Here, elements such as e.g. As, Cd, Cr, Hg, Ni, Pb, Co, Cu, Mn, Mo, Se, Zn, Ba, Tl, Ti, U, V, Al and Au are associated with feathers, as they cluster on the right side in the score plot, the same side as the feathers cluster in the loading plot. These elements are therefore likely a product of external and/or internal deposition.

The screening of elements in blood and feathers revealed that some of the analyzed elements are present at significantly higher mean concentration in blood compared with mean concentration in feathers (Table 1). For some of the elements this is obvious e.g. Fe, which is an important blood component found in hemoglobin and other enzymes, and Na, Mg, K and P which participate in physiological processes in blood and cells. For Rb, the physiological role is not so obvious. Rb concentrations in tissue samples from different organisms (vascular plants, fungus, insect, bird, rodents) have been demonstrated to closely reflect potassium and acidity conditions of forest soils (Nyholm & Tyler, 2000). K has several similarities with Rb, and the study of Nyholm and Tyler (2000) showed that low levels of K in the soil, usually aggravated by high soil acidity which causes K leaching loss, was compensated by greatly increased uptake of Rb by plants and fungi. These elevated Rb levels were subsequently distributed in the food web (Nyholm & Tyler, 2000), and could thus also end up in top predator such as tawny owls.

The tendency of certain elements to be associated with blood could also be observed in the multivariate analysis of feathers and blood for adults (Figure 2). Elements such as Fe, K, Mg, Na, P and Rb seemed to cluster on the left side of the loading plot, which is the same side as the blood samples were clustered in the score plot. These elements were found to be more attached to blood, due to the physiological role, others as a result of unintentional uptake from the environment into the blood stream (e.g. Rb).

The results from the correlation analysis (Table 3) between blood and feathers of the adult owls shows that there were significant positive correlations in two elements (Hg and Mg). Some metals will be transferred into growing feathers proportionally to the blood levels (Borghesi *et al.*, 2016), and this could be the case also for correlations in blood and feathers concentrations of Hg in the present study. According to Borghesi *et al.* (2016) the fate of e.g. Mg in flamingo feathers remained completely unknown. It might also be difficult to explain the correlation of e.g. Mg in feathers in the present study, but since Mg was positively correlated in blood and feathers it might be due to internal deposition. In addition, the correlation analysis (Table 3) between blood and feathers of the adult owls showed that there were significant negative correlations for four elements (Au, B, Na and Th). Au and Th had higher mean concentrations in feathers compared to blood (Table 1), and the significant negative correlation of these elements between blood and feathers could indicate an internal deposition from blood to feathers, e.g. the concentration in blood decreases when the elements are transferred to the feathers, and consequently the concentrations in feathers increase. If that is the case the rate of transfer is concentration-dependent. For B and Na the mean concentrations are higher in blood compared with feathers (Table 1). The negative correlation between blood and feathers is therefore more difficult to understand (Table 3). The positive correlation between concentrations of two of the elements in blood and feather in adults was according to the hypothesis. For other elements the concentrations in feathers were influenced by external contamination, thus showing weaker or no significant correlations depending on the extent of external contamination

4.1.2 Nestlings

The present study also shows the presence of a wide variety of elements at different concentrations in nestling tawny owls living in proximity to settlements and industry around the Trondheimsfjord in Central Norway. Nestling birds are potentially good biomonitors for terrestrial point-source pollution, as the contamination will originate from a limited area (Borghesi *et al.*, 2016; Burger, 1993). The screening of elements in blood and feathers of the nestling owls revealed that several elements were present at significantly higher mean concentrations in feathers compared with blood (Table 4). This includes some of the major toxic elements, e.g. As, Cr, Hg, Ni, Pb and some of the essential metals which are potential toxic, e.g. Cu, Mg, Mn, Mo, Se (non-metallic), Zn, a few of the minor toxic elements e.g. Sn, Tl, Ti, U and V, together with some of the elements which are toxic under certain conditions e.g. Al

and Au. In addition, one of the minor toxic elements Sb was only detected in the nestling feathers as the levels in blood were not detectable. This was also the case with Bi which is classified as toxic under certain conditions.

There are several routes that can contribute to the differences in concentration of elements in feathers compared with blood among the nestlings. There is an internal assimilation through uptake of pollutants in feathers from nestlings, as their feathers are still growing and thus connected to the blood stream. This means that the nestlings transfer elements to feathers from internal sources, either obtained during maternal transfer in the egg (Oraowski *et al.*, 2016) and/or through diet after hatching (Eeva *et al.*, 2009; Eeva & Lehikoinen, 1996).

Increased concentrations of elements in feathers from nestlings may also result from external contamination in various forms (atmospheric deposition, preening, sediments) described in the same manners as for adults in section 4.1.1. However, external contamination is supposed to be of less concern in nestlings since they are only two-three weeks old, and have not yet been exposed to the environment in the same way as their parents. The feathers of the nestlings were taken from the back where they were most developed, as the rest of the body was still only covered with down. In addition, the nestlings do not preen their feathers yet and have not been outside the nest box, so potential deposition could only result from inside the nest box. Dust and sediments could potentially be transferred from the mother's feather surface to the nestling's feathers during feeding time and during the time they spend together in the nest box. Borghesi *et al.* (2016) analyzed the relationship between elemental concentrations in the nest material and compared it with the wet sediments surrounding the nests in an experiment with flamingo feathers. Their study revealed a clear, significant, positive difference between most of the concentrations of elements in the nest material compared to the sediments for some of the study sites, but for other study sites, elemental concentrations in wet sediments surrounding the nest were similar to the nest material used for most samples. This shows that nest material reflects the local sediments on some occasions, and that some of the elements in the present study might be deposited onto the nestling feathers this way. At least this could explain the presence of some of the elements, such as Al, Pb, Mn, Ti and V that were found at higher concentrations in feathers compared to blood of the nestlings, as they were demonstrated by the same experiment of Borghesi *et al.* (2016) to be the result of difficulties removing all the sediments and dust in the cleaning procedure of feathers. Tawny owls do not use nest material the same way as flamingo, but they fill their nest boxes with prey and feathers, so to some extent it could also be some of the explanation here.

In this study the concentrations of Pb were significantly higher in feathers compared to blood for nestlings. The nestling concentrations for Pb were 0,006 µg/g in blood and 0,010 µg/g in feathers. Concentrations of Pb above 0,15 µg/g in blood provid a threshold concentration at which metals could affect the antioxidant systems in blood samples of Griffon vultures.(Espin *et al.*, 2014)

The tendency of certain elements to associate with feathers could also be observed in the multivariate analysis of feathers and blood for nestlings (Figure 4). Here elements such as As, Cr, Hg, Ni, Pb, Cu, Mg, Mn, Mo, Se, Zn, Sn, Tl, Ti, U and V, Al, Au, Sb and Bi seem to demonstrate associations with feathers, as they cluster on the right side of the score plot, the same side as feathers were clustered in the loading plot.

The screening of the elements in blood and feathers of the nestling revealed that some of the analyzed elements are present at significantly higher mean concentrations in blood compared to the mean concentrations in feathers, for the nestlings as well (Table 4). Elements such as Fe, which is an important blood component, and Na, Mg, K and P, that participate in physiological processes in blood and cells, are present at higher mean concentrations in nestling blood. In a similar manner to the adults, Rb is present in significantly higher mean concentrations in blood compared to feathers, and details for the possible cause are described for adults in section 4.1.1. In addition, B had a significantly higher concentration in blood compare with feathers. The physiological role of B is not so obvious, but there have been suggestions that dietary B deficiency affects normal development and plasma Ca, P and Mg levels in broiler strains (Bozkurt *et al.*, 2012). To define the mechanism through which B could compensate for the dietary Ca and P deficiency in broiler strains, data that were presented by Bozkurt *et al.* (2012) indicated that B, either at the 30 µg/g or 60 µg/g supplementation level, was effective in conversion of feed to body weight, whereas only at 30 µg/g contributed to the mineralization of bone thereby augmenting more Ca and P while excreting less through faeces. This could indicate that B has some sort of regulatory role in connection with the development of birds. The mean concentrations of B in this study for nestlings blood and feather were 0,291 µg/g and 0,138 µg/g, respectively. For Ba and Cs, the values were significantly higher in blood than in feathers, unlike for the adults. This could be due to recent internal uptake into the blood stream, which is not reflected in the feathers yet, as the nestlings are only two-three weeks old.

The tendency of certain elements to associate with blood could also be observed in the multivariate analysis of blood and feathers for nestlings (Figure 4). Elements such as B, Fe, K, Na, P and Rb clustered at the left side of the score plot, which was the same side as the blood

samples were clustering in the loading plot. These elements were associated with blood, as some of them (Fe, K, Na, P) have a physiological role in blood and cells, and others could be a result of unintentional uptake from the environment, such as Rb that compete with K due to the similarity of the two elements, as described in detail for adults in section 4.1.1.

The results from the correlation analysis (Table 6) between blood and feathers of the nestlings showed that there are significant positive correlations for eight elements (B, Hg, La, Mo, Rb, Se, Sr and U). This could indicate transfer into growing feathers proportionally to the blood levels for these elements (Borghesi *et al.*, 2016; Jaspers *et al.*, 2004). Se is most likely involved in the detoxification of Hg (Melnick *et al.*, 2010), and is probably correlated in a similar manner as for Hg in blood and feathers of nestlings for that reason. The positive correlation found between concentrations of several of the elements in blood and feathers in nestlings, and to some extent in adults, were according to the hypothesis. This was due to the transfer from the blood to the growing feathers. For other elements the concentrations in feathers were influenced by external contamination, thus showing weaker or no significant correlations depending on the extent of external contamination.

4.2 Comparison of elements in adults and nestlings

4.2.1 Blood – adult and nestlings

When comparing the blood values of all the elements tested, many of the elements (Al, Au, Ce, Cr, Cu, Fe, Gd, Hg, K, Mn, Mo, Nd, Ni, P, Pb, Rb, S, Si, Th, Ti, U and W) were present in higher mean concentrations in blood of the adults compared to blood of the nestlings (Table 1 and 4). This is also demonstrated in the multivariate analysis of adults and nestling blood (Figure 7) which shows that there is a clear tendency of these elements to cluster in the same area of the plot as the adult blood. One explanation could be that adult owls were exposed to these elements over a longer time period, and some of these elements could deposit in different compartments of the body over time, and contribute constantly to a generally higher blood level of the adult owls. Adult birds normally show a higher metal accumulation than nestlings (Burger, 1993). In addition, the adults could also have a slightly different diet than their nestlings, and metal accumulation in feathers may vary in relation to diet (Nygård *et al.*, 2001), but as a diet composition was not a part of the present experiment, this needs to be studied further. Another factor that contributes to a larger variation among the adults, is the fact that they are of different age (Burger, 1993)

Furthermore, quite a few of the elements (As, B, Ba, Cd, Ca, Co, Cs, Li, Mg, Na, Se, Sn, Sr, Tl, V, Y and Zn) were actually present in higher values in blood of the nestlings compared to the blood of the adults (Table 1 and Table 4). The same tendency could be seen in the multivariate analysis of the adult and nestling blood (Figure 7), as these elements cluster on the same side of the plot as the nestling blood. Some of the elements are among the most toxic elements (As, Cd) to living organisms. In addition, nestlings are typically more sensitive to the toxic effects of chronic metal exposure than adults, and altricial species, in which the young are incapable of moving around on their own soon after hatching such as tawny owls are often more sensitive than precocial species (Scheuhammer, 1987) The nestlings might have less developed mechanisms to eliminate or detoxify some of these elements, or they might have a different diet than the parents, or pollutants could be a transfer from females to nestlings via the in egg. Blood concentrations present a snap-shot of the concentrations at a certain time and are very much dependent on the diet (Eeva *et al.*, 2009). The group of nestlings in this area are a more similar group when it comes to age and diet at sampling time, as they are almost the same age (two-three weeks), and are dependent mostly on the same diet, based on the annual variation of the two sampling years, 2017 and 2018. From the correlation analysis there were significant positive correlations for two of the elements (Cd and Cs) in adult blood and nestling blood (Table 9), both of which have toxic activity in organisms (Casarett & Doull, 2013). Probably they are correlated due to some common diet. It could also mean that they are transferred to the nestlings during the egg stage (Oraowski *et al.*, 2016), but blood element concentrations are known to be indicative of recent dietary exposure (Fenstad *et al.*, 2017). One element shows negative correlations (Mo) in adult and nestlings blood. Mo is classified as an essential metal with potential toxicity.

4.2.2 Feathers – adults and nestlings

When comparing the feathers concentrations of all the elements tested, most of the elements (Ag, Al, As, Au, B, Ba, Bi, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Fe, Ga, Hf, Hg, Ho, La, Lu, Mn, Mo, Ni, Nd, Pb, Pr, S, Sb, Sc, Si, Sm, Sr, Tb, Th, Ti, U, V, W, Y, Yb) were present in higher mean concentrations in feathers of the adults compared to feathers of the nestlings (table 1 and 4). This was also confirmed by the multivariate analysis (Figure 6) where these elements were grouping at the same side of the plot as the adults feathers. Concentrations of many of these elements in feathers have shown to build up with increasing age of the feather (Jaspers *et al.*, 2004), and for Hg in particular, it has been demonstrated that the concentrations are primarily

due to internal deposition. As raptors molt their body feathers once a year, many of the feathers of the adults have been exposed to the environment for a longer period compared to the nestlings, both from external contamination and internal deposition. Adults have had longer time to acquire and bioaccumulate contaminants (Burger *et al.*, 2009) than the nestlings. In addition, the feathers have a slightly different composition due to the fact that adult feathers are fully formed, while the feathers of the nestlings are still growing and have an active blood circulation (Burger & Gochfeld, 1992). Once the feathers are fully formed, the blood supply is no longer needed, and the blood stream is disconnected. Several of the elements found in higher concentrations in adult feathers compared to the nestlings, are classified as major toxic elements (As, Cd, Cr, Hg, Ni, Pb). Redox inactive metals (e.g. As, Cd and Pb) have strong affinity to the sulfhydryl groups of the keratin structure in feathers (Costa *et al.*, 2013), and this could probably explain why there were higher levels of these metals in the fully formed adult feathers. In addition, the body burden of metals in adults can be higher because of accumulation with age (Burger, 1993).

Some of the elements tested (Ca, K, Li, Mg, Na, P, Rb, Se, Tl, Zn) were present in higher levels in feathers of the nestlings compared to the feathers of the adults. This was also seen in the multivariate analysis (Figure 6), as these elements were clustering at the same side as the nestling feathers. Some of these elements are important for feather formations (Zn), and could explain why the concentrations are higher in the nestlings' developing feathers compared to the adults' feathers. According to Jaspers *et al.* (2004) contaminations with Zn is probably due to internal deposition. The nestlings had small, growing feathers at the sampling time (2-3 weeks), and the structure of the feathers were a bit different than the adults, they were smaller and had less barbs, and seemed more stiff, as they were not fully developed. Nestling feathers include blood vessels, as they are still developing (Burger & Gochfeld, 1992), and blood might contain more Zn than pure keratin (Costa *et al.*, 2013). In section 4.1.2 where blood and feathers were compared for the nestlings, the concentrations of some of the same elements were present at higher levels in blood (Na, Mg, K, P, Rb). As the developing feathers of the nestlings still are connected to the blood stream and contain blood, this could be the possible reason for feathers of nestlings having higher concentrations of these elements compared to the adult feathers. Furthermore, the differences between adult and nestling feathers could indicate that the nestlings might have a different diet to the adults. In addition, there could have been transfer of some elements during the egg stage (Oraowski *et al.*, 2016), that were deposited into the developing feathers as they were formed.

The correlation analysis (table 9), showed that there were significant positive correlations between adult feathers and nestling feathers in as many as 22 elements (Al, As, Au, Ba, Ce, Co, Cr, Dy, Er, Fe, Hg, La, Mn, Nd, Pr, S, Sm, Sr, U, V, Y and Yb). A correlations analysis was also performed by analyzing adult feathers vs. nestling blood and adults blood vs. nestling feathers (Table 9). First, significant positive correlations were found between adults feather and nestling blood for three elements (Ba, Hg and Se). This indicates that these three elements are taken up into the blood stream by the nestlings either through a similar diet as the adults, as the adults deposit the same elements into their feathers, or through maternal transfer, which will reflect the condition of the mother in the blood of the nestlings. Secondly, there were significant positive correlations for three elements (As, Hg and Se) between adult blood and nestling feathers, and negative correlation in one element (Au). This may have an implication to the biomonitoring in Tawny owls, as you can use nestling feathers to also indicate levels in the blood of both nestlings and adults for those elements. The findings in these correlation analyses were according to the hypothesis, as positive correlations between concentrations of elements in blood and feathers for some of the elements were found and might be due to maternal transfer from females to nestlings via the egg. In addition, higher concentrations of several elements were found in adult females compared to their nestlings, as a result of adults having longer time to bioaccumulate contaminants compared to nestlings.

4.3 Analysis of habitat variations and annual variations

4.3.1 Elements in blood in relation to land use, sampling years and municipalities

From the multivariate analysis of the comparison of elements in blood of adults vs. land use, sampling years and municipalities (Figure 9) the score plot shows that there is a weak division in elements in blood between the two sampling years (2017/2018). This could have several explanations, but one important reason could be related to different diet between the two different sampling years. The concentrations in blood is a snap-shot of the concentrations at a certain time, and will most likely reflect the natural variations between two years related to different diet (Eeva *et al.*, 2009). As mentioned in Cramp (1985), tawny owls are generalists and they have the possibility to adapt to the conditions from year to year. This could have a significant impact on the elemental composition in the blood. Another explanation could be that only a few of the owls that were analyzed in both years are the same individuals. There was a surprisingly high exchange of adult owls in the territories among the two years as only 5 of 28

blood samples are from the same individuals in the field seasons of 2017 and 2018. New individuals will lead to individual differences. Several of the elements (e.g. As, B, Ba, Cr and Mn) seemed to be associated with samples from 2018 and the land use of ocean and freshwater. For blood there was two sampling years only, and this period of time is very limited for revealing annual trends within the tawny owls.

Some of the elements (e.g. Cu, Cs, Hg, Zn and Rb) seemed to covary in samples from both sampling years (2017/2018), indicating that these elements are equally represented in the two seasons of blood sampling. Forest and bogs are more represented where these elements are clustered, and the distance to industry and distance to road also seemed to covary with these elements. For forest and bogs, this could indicate that these elements are present at higher concentrations in relation to these areas of land uses, e.g. Rb in forest (Nyholm & Tyler, 2000), but for the distance to pollution source analysis it means that the concentrations of these elements will e.g. decrease with decreasing distance to the source, as they are measured in meters. The division between the different municipalities is not obvious, and could relate to the fact that the five municipalities are very similar. They all consist of small settlements, some industry and roads, and large areas of agricultural land. A comparison with other regions nationally or internationally would have been interesting, and could be studied further. Some of the elements (e.g. Cd, Pb, Mg) seem to be associated with samples of 2017, and the samples seemed to originate mainly from the municipalities of Levanger and Verdal, indicating that the levels of these elements were highest in 2017 in these areas. This could be related to different diet in 2017 compared to the hatching season of 2018. There seemed to be a weak association between these elements and the landscape types “other-land” (football fields, mountains and rocks etc.) and distance to coast. It was difficult to interpret why these elements were associated to “other-land” in the PCA. For the association with distance to coast, the concentrations of these elements will increase with increasing distance to coast. These two municipalities are among the most densely populated areas in the northern part of Central Norway.

4.3.2 Elements in feathers in relation to land use, sampling years and municipalities

From the multivariate analysis of the comparison of elements in feathers of adults in relation to land use, sampling years and municipality in Figure 10, there were a clear tendency for all the elements to cluster at the right side of the plot where most of the samples from 2017 and some of the samples from 2018 were clustering. This could indicate that body feathers especially from 2017 were more contaminated either from external or internal depositions. As tawny owls

moult their body feathers once a year (Solheim & Vedum, 2017), the load in the measured body feathers mainly originate from exposure within the last year. The degree of internal and external exposure are most likely related to a combination of dietary variations (Nygård *et al.*, 2001) and external deposition that can vary due to various reasons (climate, weather, snow cover, pH etc.) between years (Bustnes *et al.*, 2013; Nygård *et al.*, 2012).

On the left side of the loading plot there were mainly samples from 2016 and some from 2018 that were clustered. There were no positive associations between the samples on the left side and any of the elements. On the other hand, there were positive associations between these samples and the body mass and the wing length of the owls. In addition, there were negatively associations between these samples and several of the elements that were clustered at the outmost right part of the loading plot (e.g. Cr, Cs, Mn and Ni and many of the rare earth elements). Furthermore, the body mass and especially the wing length seemed to be negatively associated with the concentrations of these elements. In that case this could indicate that larger birds (greater body mass and longer wings) might have lower concentrations of these elements. These samples seemed to be spread on several municipalities, but most of them seemed to originate from the municipalities of Verdal, Verran and Levanger. There were not any obvious connections between these elements and the different land uses, except for Mo which seemed to be weakly associated to ocean.

4.3.3 Correlation analysis

Although the results from the PCA for feathers and especially blood did not show clear tendencies in relation to land use, the correlation analysis showed quite a few significant correlations. Some of the most important correlations from each different land use were summarized in Table 12, and these elements are the focus of the discussion in this section.

4.3.3.1 Settlements

For the settlements, the most interesting correlations were (Fe, Mg) in adult blood (B, Bi) in adult feathers and (Hg, Zn and Sb) in nestling feathers. The correlations in adults were most likely implying a recent uptake into the blood stream of Fe and Mg through the diet, and that these elements could be related to local sources from the settlements within the territory. Several studies have demonstrated a higher concentration of metals in urban vs. rural areas (Abbasi *et al.*, 2015b; Eeva *et al.*, 2009; Eeva & Lehikoinen, 1996). Tawny owls are restricted

to their territory throughout the year (Cramp, 1985), and through their diet. The birds represent elemental concentration in their foraging area well (Burger, 1993; Nygård *et al.*, 2001).

Fe and Mg are both essential metals with potential for toxicity (Casarett & Doull, 2013). As the nestlings did not show the same tendency in blood related to settlements, it could indicate a different diet between the adults and the nestlings.

Some of the elements were showed positive correlations in feathers of adults and nestlings in relation to settlements. Concentrations of Zn in feathers have been described in other studies to originate from internal sources (Borghesi *et al.*, 2016). This means that as Zn had higher concentrations in relation to increasing settlements in feathers of the nestlings, the Zn sources could possibly be related to local release connected somehow to the settlements. Roads and human residence are pooled into the GIS-parameter settlements in the present study, both of which could affect the available levels of Zn as well as the concentrations of B, Sb and Bi in the environment. The results from a study performed by Nygård *et al.* (2012) revealed that local point sources of pollution provide significant contributions to the soil concentrations of e.g. Zn. However, both Zn and Bi in Norway have also been demonstrated by other studies to partly originate from industrialized parts of Europe through long-range transport (Nygård *et al.*, 2012; Steinnes *et al.*, 2011).

4.3.3.2 Agricultural land

For the agricultural land the most interesting elements were (Co, Li,) in adults blood, (Sb) in adult feathers and (Sb) in nestlings feathers. Co has been used as a food additive for domestic ruminants as the Co status is crucial for the construction of the Co-containing vitamin B_{12}, and thus very important for the growth and health of livestock (Underwood, 1975). It is also used in fertilizing meadow and pasture areas (Bakken *et al.*, 2004). These events could both contribute to the increased Co concentration in adult tawny owl blood in relation to the area of agricultural land within their territory. The demand for Li has increased significantly during the last decade as it has become a key element for the development of several industrial products (Talens Peiro *et al.*, 2013). How the levels of Li in adults blood could connected to agricultural is harder to explain, but the general amount of Li in the environment are probably increasing alongside the extended use. Antimony (Sb) is an important element which is widely used industrially, especially in production of flame retardants, and in recent years, Sb has gained increasing research attention due to its elevated concentrations in the environment and its

toxicity (Ren *et al.*, 2019). As the element was correlated positively with the amount of agriculture, it could be a result of increased environmental concentrations, or the fact that industrial products, and/or antimony-containing flame retardant could be more used in connection with agricultural practices. Sb is one of the elements known to be enriched in the surface environment for purely natural reasons, due to a strong tendency to organic binding (Reimann *et al.*, 2010). In that case the different soil types will be of interest, and agricultural land might have higher concentrations of organic matter.

4.3.3.3 Forest

For forest the most interesting elements that correlated were (Rb) in adult blood, (Hg) in adult feathers, (Cs, Rb) in nestling blood, and (Cs) in nestling feathers. Rb concentrations in tissues from different organisms have been demonstrated to closely reflect potassium and acidity conditions of forest soils (Nyholm & Tyler, 2000). K has several similarities with Rb, and the study of Nyholm and Tyler (2000) showed that low levels of K in the soil (usually affected by high soil acidity which causes K leaching losses) was compensated by greatly increased uptake of Rb by plants and fungi. These elevated Rb levels were consequently distributed throughout the food web. In the present study the Rb concentrations were correlated in the blood of both adults and nestlings in relation to the amount of forest within the territory. This may be an indication of high soil acidity, and low levels of K in the forests of Central Norway. No additional analyses were performed to support this in the present study. The main source of Hg in Scandinavia is long-range transported atmospheric pollution (Larssen *et al.*, 2008). Much of the deposited Hg is stored in the soil, but some is transported to rivers and lakes. Boreal forest catchments, especially those containing wetlands, are important sources of MeHg for downstream aquatic systems in Scandinavia (Larssen *et al.*, 2008). Hg is known to be excreted into feathers during feather formation, thus the correlations observed between the amount of forest and Hg concentrations in adult feathers could be explained by this. Norway was one of the countries outside the former Soviet Union that were mostly affected by the 1986 Chernobyl accident, with particularly high deposition of radioactive Cs (^{137}Cs) in the central parts of the country (Backe *et al.*, 1987). This has resulted in significant ^{137}Cs exposure for sheep, goats, cattle, and domestic reindeer grazing in areas of forest and mountains during the summer season. In addition, the amount of Cs available to plants is due to competition in uptake with other ions, and a well-known example is the influence of the soil K^+ concentration on uptake of

^{137}Cs in plants (Thørring *et al.*, 2012). As mentioned for Rb, high soil acidity could lead to low levels of K and thus lead to higher uptake of Cs in forest ecosystems, as well.

4.3.3.4 Freshwater lakes

For freshwater lakes the most interesting elements were (Hg, Pb) in adult blood, (Al, Co) in adult feathers, and (Hg) in nestling feathers. According to Evers *et al.* (2008) some areas could be more sensitive to sulphate deposition and subsequent acidification of lakes and therefore are even more sensitive to the deposition of atmospheric Hg. Low pH in lake systems is one factor associated with enhanced MeHg concentrations in surface water. Hg in freshwater lakes was correlating with both adult blood and nestling feathers (which is connected to the blood stream as they still are developing) in the present study. This could indicate that the tawny owls in this area are reflecting the concentrations of Hg in the surface water within their territory well, as blood concentrations in birds are known to reflect the diet at the actual time (Eeva *et al.*, 2009). MeHg is known to be biomagnified along the food web (Burger, 1993), and might be the case for the correlations between the owls and freshwater lakes.

In the blood of the adult owls there was a correlation for Pb in relation to the amount of freshwater lakes in the territory, and some of the lakes are used as a source of drinking water. Norway is mainly a soft water area, with generally low pH and mineral concentrations (Dahl *et al.*, 2014). When the water is soft, the concentration and toxicity, along with the uptake of metals, are often larger than when the water is hard (Crawford & Clayton, 1973). This particular study of Dahl *et al.* (2014) investigated the relations between Cd, Pb, and Al in municipality drinking water, and the incidence of hip fractures in the Norwegian population. There has been a reduction in acid rain pollution and fuel containing Pb the last two decades, and this has caused a higher pH and a reduced supply of many metals (Cd, Pb, and Al) into drinking water (Dahl *et al.*, 2014).

Al is present in all natural water sources, and the total concentrations in Central Norway was shown to be highest during early spring flood and during summer and autumn rain episodes in a study of Gundersen and Steinnes (2001). Al measured in feathers is known to be mostly connected to external depositions (Borghesi *et al.*, 2016), and the positive correlation with feathers and freshwater lakes could be connected to the higher concentrations of this element during the spring when the feathers were collected. pH is one of the factors that is most crucial to the availability of Al in freshwater lakes (Gundersen & Steinnes, 2001).

Co showed a correlation in adult feathers in relation to the amount of freshwater lakes. Co was also correlated with the amount of agricultural land, and these two correlations may be connected with each other. It is known that Co is applied to agricultural land during fertilizing of meadow and pasture areas (Bakken *et al.*, 2004). Consequently, runoff from fertilized agricultural land would lead to an increased level of Co in the surrounding surface waters.

4.3.3.5 Distance to roads

In the correlation analysis of the elemental concentrations in adults and the distance to roads (in m) there were no interesting correlations in any of the tested elements in blood and feathers from adults or nestlings. The only significant correlation was Hg, but as the correlation was positive, it means that the concentrations decrease when the distance to industry decreases. There are most likely other factors in this area that are important for Hg concentrations.

4.3.3.6 Distance to industry

For the correlations of elements in relation to distance to industry (in m) the most interesting correlation was the negative correlation in (Sr) in nestling blood. The negative correlation with increasing distance in meters means that the elemental concentration increases in the nestlings blood the closer they are to industry. The reason is difficult to interpret, but generally the levels of Sr in the investigated part of Central Norway have been elevated due to the atmospheric fallout of Sr after the nuclear power plant accident of Chernobyl in 1986, which released a large amount of Sr into the atmosphere (Gupta & Walther, 2018). The central part of Norway was particularly affected, and the nuclear accident required decades of management and rehabilitation of living conditions. The time period is dependent on a number of factors, e.g. amount of fallout, type of radionuclides and land use of contaminated area (Liland *et al.*, 2009). The results from the correlations analyses were according to the hypothesis, since positive correlations in concentrations of some elements in relation to the area of different land use (settlements, agricultural land, freshwater lakes and forest) were detected, as a result of increased anthropogenic activities that have made metals and other elements more available for exposure to organisms.

5 Conclusions

The study concluded that there were a total of 30 elements in adults and 27 elements in nestlings that had significantly higher concentrations in whole blood feather samples compared to blood. In addition, this study identified a total of 6 elements (Fe, Na, Mg, K, P, Rb) in adults and 7 elements (B, Cs, Fe, Na, K, P, Rb) in nestlings that had significantly higher concentrations in blood, compared to feathers. Two of the elements (Hg and Mg) correlated positively between blood and feathers from adults and eight of them (B, Hg, La, Mo, Rb, Se, Sr, U) correlated positively in nestlings. This could indicate a transport of these elements into growing feathers, proportional to the blood levels. This means that the non-invasive technique of feather sampling of the adult owls could reveal the concentrations of Hg and Mg in their blood, and sampling of nestling feathers could reveal the concentrations of B, Hg, La, Mo, Rb, Se, Sr and U in the nestling blood in a biomonitoring of tawny owls. The other elements are related to the structure of feathers and some of them most likely originate from external contaminations. These results thus confirmed the first hypothesis, where the expectations were to find a positive correlation between concentrations of elements in blood and feathers in nestlings, and to some extent in adults, due to the transfer from the blood to the growing feathers. For some elements, the concentrations in feathers were expected to be influenced by external contamination, thus showing weaker or no significant correlations depending on the extent of external contamination.

When comparing feather elemental concentrations between adults and nestlings, 42 elements had higher mean concentrations in feathers of the adults compared to the nestlings. This may be a result of the fact that concentrations build up with increasing age of feathers, as adults have a longer time to acquire and bioaccumulate contaminants. The adult feathers might have a slightly different composition, as they are fully formed, compared to the developing feathers of the nestlings. 10 elements were found in higher mean concentrations in nestling feathers compared to adult feathers, and these elements seem to mainly originate from the blood within the developing feather of the nestlings. As many as 22 elements were positively correlated between the nestling and adult feathers, many of them probably due to external deposition (from mother, from nest materials and wet and dry deposition). When comparing blood levels between adults and nestlings, 22 elements had higher mean concentrations in blood of the adults compared to blood of the nestlings, and 17 elements were present at higher mean concentrations in blood of nestlings compared to adults. Adults are generally more exposed to elements than nestlings, and/or they might have a different diet. Two elements were positively correlated

between adult blood and nestling blood (Cd and Cs), and this means that for these two elements it might be possible to use either adults blood or nestlings blood in biomonitoring which covers both. There were positive correlations between adult feather and nestling blood for Ba, Hg and Se, and this might indicate the possibility to use adult feathers to biomonitor nestling blood concentrations. In addition there was a positive correlation between adult blood and nestling feathers for As, Hg, and Se, which could indicate the possibility to use the non-invasive technique of feather sampling of the nestlings to biomonitor the blood concentrations of these three elements in the adults. These results thus confirmed the second hypothesis where the expectations were to find a positive correlation between concentrations of elements in blood and feathers for some of the elements due to maternal transfer from females to nestlings via the egg. In addition, it was hypothesized to find higher concentrations of several elements in adult females compared to their nestlings since adults have had longer time to bioaccumulate contaminants compared to nestlings.

Results from the correlation analysis of the elemental concentrations in blood and feather of adults and nestlings in relation to the different land uses showed several significant correlations. The relationships between certain elements and land uses were specific to the sample type: feather versus blood, adult versus nestling. For those few cases, biomonitoring of the relevant age and body tissue could help in assessing pollution levels in these habitats. These results thus confirmed the third hypothesis where the expectations were to find positive correlations in concentrations of some elements in relation to the area of different land use, such as settlements, agricultural land, freshwater lakes and forest, since increased anthropogenic activities have made metals and other elements more available for exposure to organisms.

6 Literature

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7 Appendix

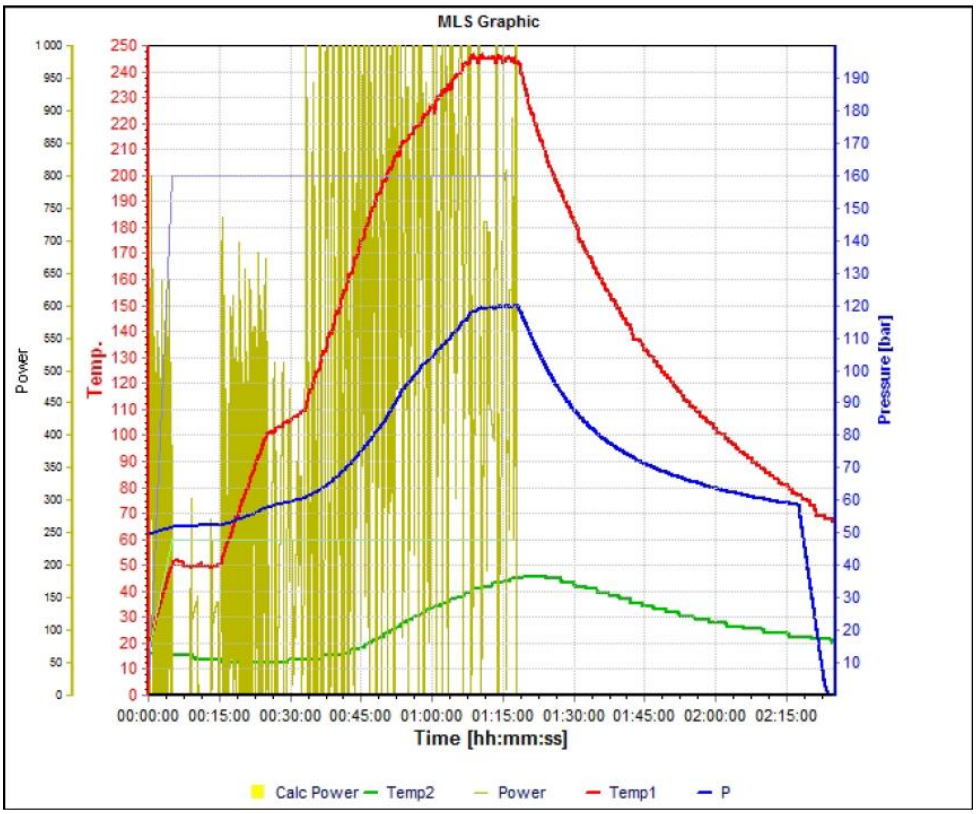

Figure A1. Temperature profile of digestion in an Ultra Clave from Milestone (curves are showing power, time and pressure)

Table A1. Table with time, temperature, pressure and energy used during the Ultra Clave running.

MW Program

Step	Time [hh:mm:ss]	Temp 1 [°C]	Temp 2 [°C]	Press [bar]	Engery [Watt]
1	00:05:00	50	60	160	1 000
2	00:10:00	50	60	160	1 000
3	00:10:00	100	60	160	1 000
4	00:08:00	110	60	160	1 000
5	00:15:00	190	60	160	1 000
6	00:05:00	210	60	160	1 000
7	00:15:00	245	60	160	1 000
8	00:10:00	245	60	160	1 000

Table A2. Principal component analysis performed on adults and nestlings - feathers and blood. The four first component are significant and explain 67% of variation.

Component	R2X	R2X(cum)	Eigenvalue	Q2	Limit	Q2(cum)	Significance	Iterations
0	Cent.							
1	0.404	0.404	29.1	0.384	0.0187	0.384	**R1**	9
2	0.111	0.515	7.99	0.134	0.0189	0.466	**R1**	52
3	0.0882	0.603	6.35	0.129	0.0192	0.535	**R1**	37
4	0.0669	0.67	4.82	0.104	0.0194	0.584	**R1**	21

a) b)

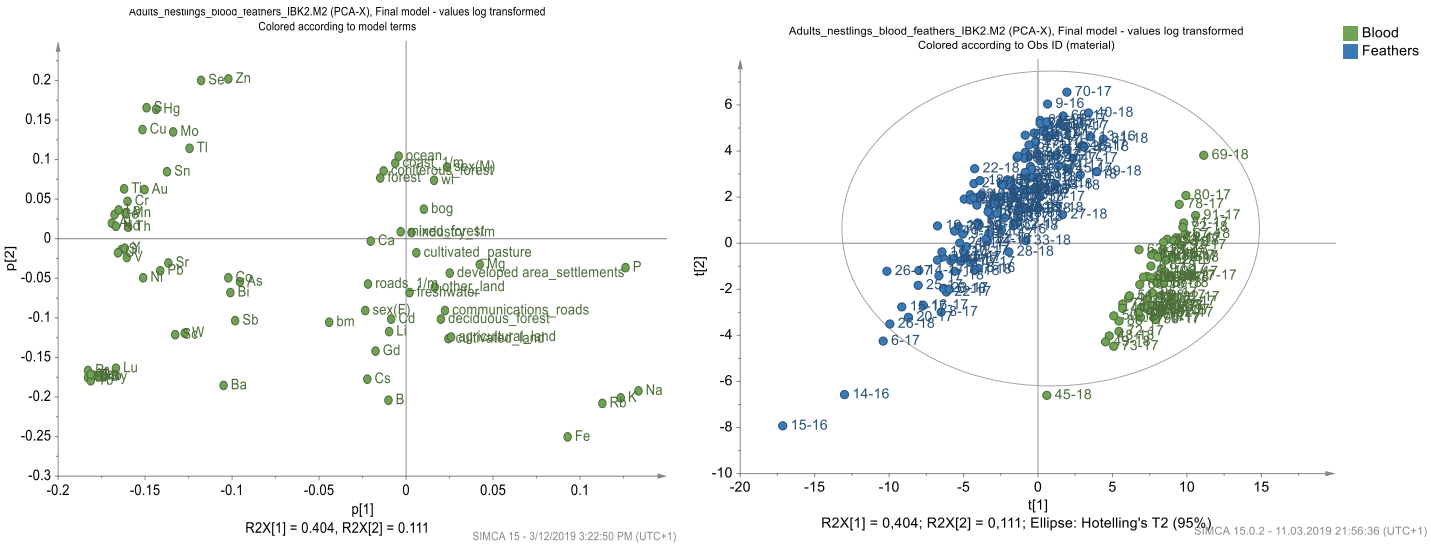

Figure A2. **a)** The loading plot and **b)** the score plot from the Principal Component Analysis of adults and nestlings, feathers and blood. Hotelling's T2 ellipse (95%) with three outliers.

Table A3. Principal component analysis performed on nestlings blood. The two first component are significant and explain 49,5% of variation.

Component	R2X	R2X(cum)	Eigenvalue	Q2	Limit	Q2(cum)	Significance	Iterations
0	Cent.							
1	0.385	0.385	13.5	0.316	0.048	0.316	R1	12
2	0.11	0.495	3.84	0.061	0.0492	0.358	R1	32
3	0.0787	0.574	2.75	-0.0448	0.0505	0.329	R2	66

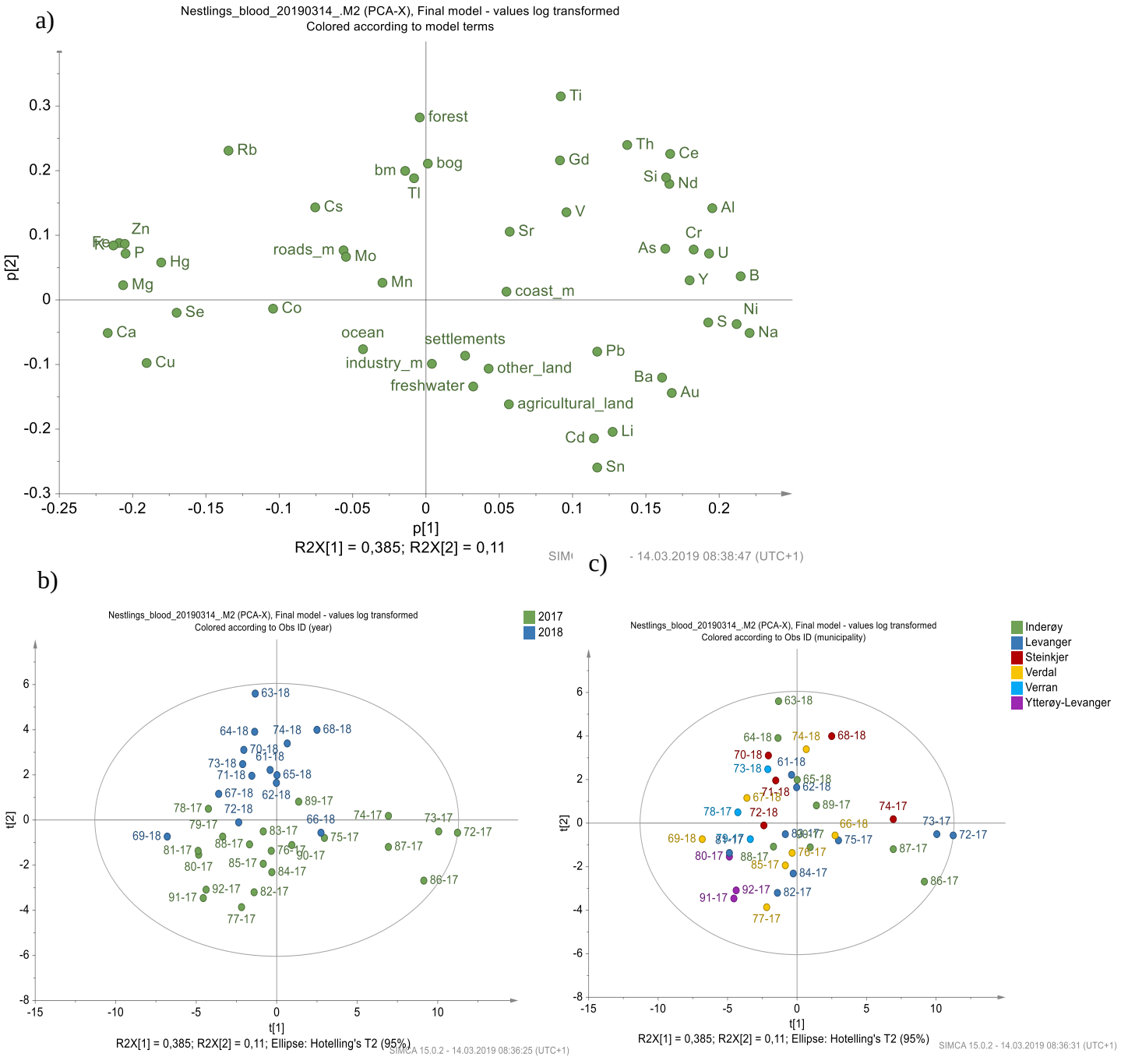

Figure A3. Principal component analysis (of component one and two) of nestlings blood **a)** The loading plot and **b)** the score plot of sampling years and **c)** the score plot of the six different municipalities/areas

Table A4. Principal component analysis performed on nestlings feathers. The four first components explain 58,5% of the variation. The first and the fourth component is significant.

Component	R2X	R2X(cum)	Eigenvalue	Q2	Limit	Q2(cum)	Significance	Iterations
0	Cent.							
1	0.314	0.314	18.5	0.272	0.0328	0.272	R1	11
2	0.105	0.419	6.2	0.023	0.0333	0.288	R2	90
3	0.0935	0.512	5.52	0.0191	0.0339	0.302	R2	43
4	0.0729	0.585	4.3	0.0532	0.0345	0.339	R1	37
5	0.0568	0.642	3.35	0.0169	0.0351	0.35	R2	40

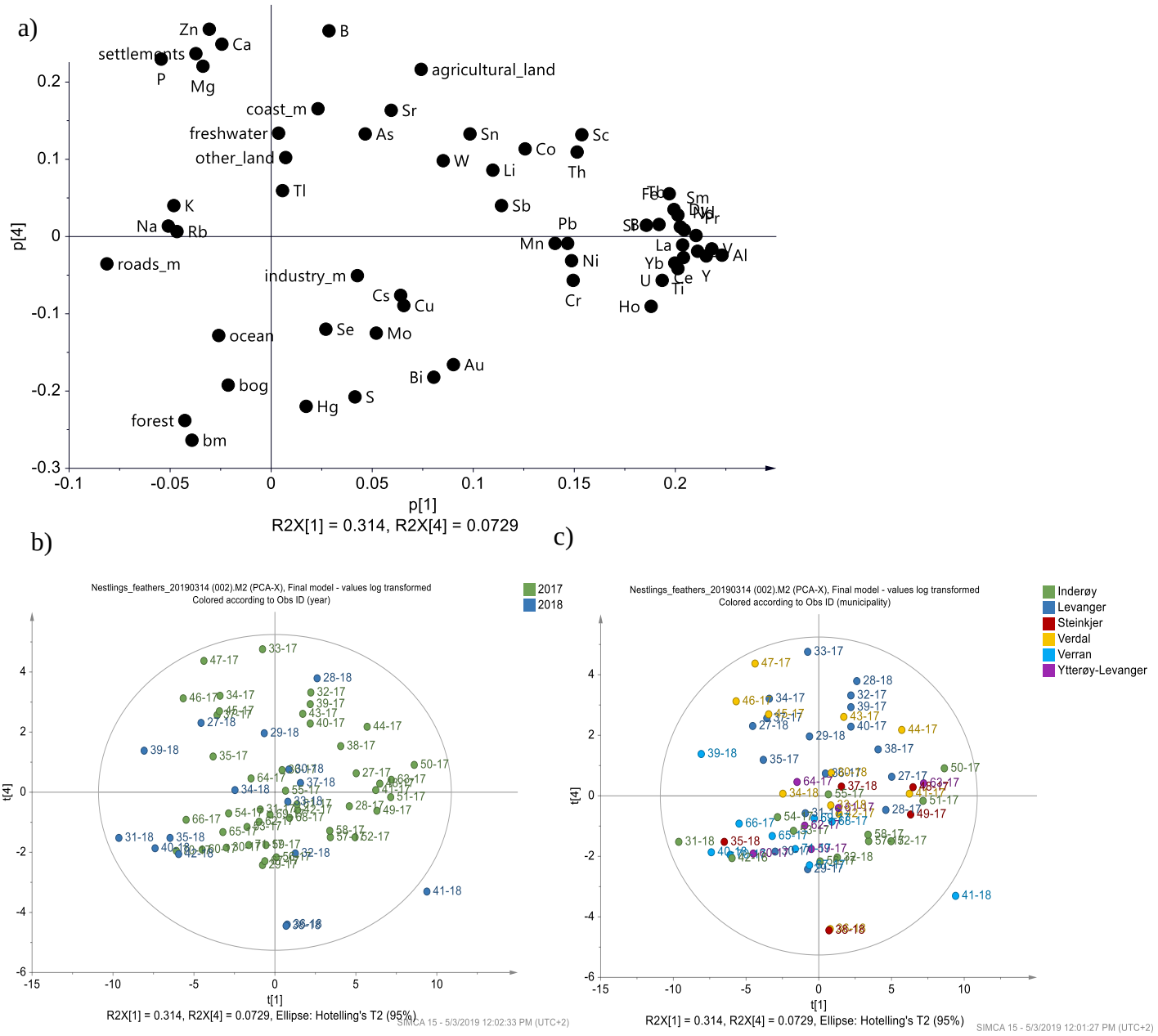

Figure A4. Principal component analysis (component one and component four) of nestlings feathers **a)** The loading plot with the different land use **b)** score plot of sampling years and **c)** score plot of the six different municipalities/areas

Table A5. Principal component analysis performed on adults and nestlings feathers. The four first components explain 66,6% of the variation, and they are all significant.

Component	R2X	R2X(cum)	Eigenvalue	Q2	Limit	Q2(cum)	Significance	Iterations
0	Cent.							
1	0.446	0.446	27.2	0.425	0.0235	0.425	R1	9
2	0.106	0.552	6.47	0.129	0.0238	0.499	R1	15
3	0.0607	0.613	3.7	0.0242	0.0242	0.512	R1	50
4	0.0527	0.666	3.22	0.0773	0.0245	0.549	R1	34

Figure A5. Principal component analysis (with component one and three) of adults and nestlings feathers **a)** The loading plot with the different land use **b)** the score plot of sampling years and **c)** the score plot of the six different municipalities/areas (Ytterøy is an island in Levanger)

Table A6. Pearson correlation between the concentrations of 41 and 52 elements in adults blood (n=28) and adults feathers (n=72), respectively, and the amount of settlements within each habitats in m^2. Significant correlations are bold.

	adults blood - settlements			adults feathers - settlements		
	n	r	p	n	r	p
Ag	28	ND		72	0,125	0,296
Al	28	-0,054	0,785	72	-0,006	0,960
As	28	-0,200	0,307	72	-0,060	0,616
Au	28	-0,097	0,622	72	0,122	0,306
B	28	-0,170	0,388	72	0,331	**0,005**
Ba	28	-0,082	0,680	72	0,016	0,892
Bi	28	ND		72	0,262	**0,026**
Ca	28	-0,175	0,374	72	0,332	**0,004**
Cd	28	0,149	0,448	72	-0,069	0,563
Ce	28	-0,052	0,794	72	-0,017	0,885
Co	28	-0,022	0,912	72	-0,103	0,389
Cr	28	-0,076	0,700	72	-0,003	0,979
Cs	28	-0,232	0,234	72	-0,014	0,906
Cu	28	0,268	0,168	72	-0,032	0,792
Dy	28	ND		72	-0,004	0,972
Er	28	ND		72	-0,015	0,898
Fe	28	0,455	**0,015**	72	-0,012	0,921
Ga	28	ND		72	-0,014	0,907
Gd	28	0,038	0,849	72	ND	
Hf	28	ND		72	-0,043	0,718
Hg	28	-0,065	0,743	72	-0,129	0,281
Ho	28	ND		72	-0,016	0,894
K	28	0,468	**0,012**	72	0,020	0,867
La	28	-0,056	0,777	72	-0,025	0,832
Li	28	-0,013	0,948	72	ND	
Lu	28	ND		72	-0,021	0,861
Mg	28	0,414	**0,029**	72	-0,005	0,965
Mn	28	-0,120	0,542	72	-0,059	0,623
Mo	28	-0,031	0,875	72	-0,059	0,622
Na	28	-0,293	0,131	72	0,063	0,601
Nd	28	-0,053	0,791	72	-0,027	0,825
Ni	28	-0,080	0,687	72	-0,026	0,830
P	28	0,489	**0,008**	72	0,076	0,528
Pb	28	0,078	0,695	72	0,009	0,941
Pr	28	-0,179	0,362	72	-0,025	0,835
Rb	28	-0,179	0,362	72	0,016	0,893
S	28	0,222	0,257	72	0,136	0,254
Sb	28	ND		72	0,159	0,183
Sc	28	ND		72	-0,020	0,868
Se	28	-0,023	0,907	72	-0,037	0,760
Si	28	-0,074	0,710	72	0,011	0,930
Sm	28	-0,070	0,723	72	-0,019	0,877
Sn	28	ND		72	0,011	0,928
Sr	28	-0,192	0,328	72	-0,023	0,849
Tb	28	ND		72	-0,009	0,938
Th	28	-0,095	0,630	72	-0,018	0,879
Ti	28	-0,069	0,726	72	-0,014	0,908
Tl	28	-0,100	0,613	72	-0,015	0,898
U	28	-0,062	0,755	72	-0,037	0,757
V	28	0,121	0,539	72	-0,023	0,850
W	28	-0,086	0,665	72	-0,044	0,711
Y	28	-0,039	0,844	72	-0,011	0,930
Yb	28	ND		72	-0,014	0,908
Zn	28	0,372	0,051	72	-0,051	0,668

Table A7. Pearson correlation between the concentrations of 38 and 48 elements in nestlings blood (n=35) and nestlings feathers (n=61), respectively, and the amount of settlements within each habitats in m^2. Significant correlations are bold.

	nestlings blood - settlements			nestlings feathers - settlements		
	n	r	*p*	*n*	r	*p*
Al	35	-0,086	0,623	61	-0,192	0,139
As	35	-0,139	0,424	61	0,019	0,882
Au	35	0,029	0,870	61	-0,094	0,473
B	35	-0,046	0,794	61	0,016	0,902
Ba	35	0,032	0,858	61	-0,033	0,801
Bi	35	ND		61	-0,159	0,221
Ca	35	0,042	0,809	61	0,294	**0,021**
Cd	35	0,103	0,556	61	ND	
Ce	35	-0,178	0,306	61	-0,175	0,177
Co	35	-0,023	0,898	61	-0,185	0,154
Cr	35	-0,062	0,724	61	-0,105	0,421
Cs	35	-0,101	0,562	61	-0,082	0,531
Cu	35	0,027	0,879	61	-0,068	0,602
Dy	35	ND		61	-0,159	0,222
Er	35	ND		61	-0,157	0,228
Fe	35	0,047	0,787	61	-0,144	0,268
Gd	35	-0,005	0,980	61	ND	
Hg	35	-0,180	0,302	61	-0,261	**0,043**
Ho	35	ND		61	-0,213	0,099
K	35	0,098	0,576	61	0,065	0,619
La	35	ND		61	-0,182	0,161
Li	35	0,065	0,711	61	-0,102	0,434
Mg	35	0,157	0,369	61	0,320	**0,012**
Mn	35	0,000	1,000	61	-0,034	0,797
Mo	35	0,327	0,055	61	0,115	0,376
Na	35	-0,087	0,621	61	0,055	0,676
Nd	35	-0,092	0,599	61	-0,178	0,171
Ni	35	0,031	0,862	61	-0,032	0,807
P	35	0,086	0,625	61	0,134	0,303
Pb	35	-0,001	0,996	61	0,076	0,561
Pr	35	ND		61	-0,172	0,185
Rb	35	0,108	0,537	61	0,091	0,486
S	35	-0,046	0,792	61	-0,101	0,440
Sb	35	ND		61	0,277	**0,031**
Sc	35	ND		61	-0,060	0,648
Se	35	-0,105	0,548	61	-0,086	0,508
Si	35	-0,096	0,584	61	-0,112	0,391
Sm	35	ND		61	-0,161	0,214
Sn	35	0,019	0,916	61	-0,079	0,547
Sr	35	0,210	0,226	61	0,189	0,144
Tb	35	ND		61	-0,073	0,579
Th	35	-0,063	0,720	61	0,000	1,000
Ti	35	-0,093	0,597	61	-0,171	0,188
Tl	35	-0,304	0,076	61	-0,042	0,745
U	35	-0,139	0,425	61	-0,136	0,298
V	35	-0,071	0,685	61	-0,152	0,242
W	35	ND		61	0,326	**0,010**
Y	35	-0,020	0,909	61	-0,130	0,317
Yb	35	ND		61	-0,181	0,164
Zn	35	0,059	0,737	61	0,265	**0,039**

Table A8. Pearson correlation between the concentrations of 41 and 52 elements in adults blood (n=28) and adults feathers (n=72), respectively, and the amount of agricultural land within each habitats in m^2. Significant correlations and p-values are bold.

	Adults blood - agriculture			Adults feathers - agriculture		
	n	r	*p*	*n*	r	*p*
Ag	28	ND		72	0,214	0,072
Al	28	0,258	0,186	72	-0,127	0,289
As	28	0,062	0,753	72	0,012	0,924
Au	28	0,072	0,715	72	0,186	0,117
B	28	0,006	0,977	72	-0,157	0,188
Ba	28	**-0,388**	**0,042**	72	-0,144	0,229
Bi	28	ND		72	-0,082	0,496
Ca	28	0,112	0,570	72	0,008	0,947
Cd	28	0,057	0,774	72	-0,068	0,572
Ce	28	0,246	0,207	72	-0,147	0,219
Co	28	**0,590**	**0,001**	72	-0,149	0,211
Cr	28	0,359	0,060	72	-0,187	0,116
Cs	28	**-0,511**	**0,006**	72	-0,127	0,288
Cu	28	0,023	0,908	72	0,093	0,438
Dy	28	ND		72	-0,118	0,325
Er	28	ND		72	-0,132	0,270
Fe	28	-0,341	0,075	72	-0,121	0,311
Ga	28	ND		72	-0,129	0,281
Gd	28	0,161	0,412	72	ND	
Hf	28	ND		72	-0,141	0,237
Hg	28	-0,254	0,193	72	**-0,518**	**<0,0001**
Ho	28	ND		72	-0,121	0,311
K	28	-0,066	0,739	72	-0,112	0,351
La	28	0,235	0,228	72	-0,145	0,223
Li	28	**0,381**	**0,045**	72	ND	
Lu	28	ND		72	-0,129	0,281
Mg	28	0,017	0,933	72	-0,089	0,456
Mn	28	-0,037	0,852	72	-0,158	0,186
Mo	28	0,036	0,854	72	-0,139	0,243
Na	28	0,203	0,300	72	-0,080	0,505
Nd	28	0,237	0,225	72	-0,140	0,241
Ni	28	0,316	0,102	72	-0,079	0,510
P	28	-0,221	0,258	72	-0,161	0,176
Pb	28	-0,157	0,425	72	0,166	0,164
Pr	28	ND		72	-0,144	0,228
Rb	28	**-0,375**	**0,049**	72	-0,125	0,297
S	28	-0,142	0,470	72	-0,059	0,625
Sb	28	ND		72	**0,291**	**0,013**
Sc	28	ND		72	-0,128	0,284
Se	28	-0,098	0,620	72	**-0,274**	**0,020**
Si	28	0,148	0,451	72	-0,138	0,249
Sm	28	0,227	0,244	72	-0,137	0,251
Sn	28	ND		72	0,121	0,309
Sr	28	0,067	0,736	72	-0,140	0,241
Tb	28	ND		72	-0,127	0,289
Th	28	0,194	0,323	72	-0,139	0,245
Ti	28	0,237	0,225	72	-0,148	0,215
Tl	28	0,360	0,060	72	0,005	0,969
U	28	0,143	0,468	72	-0,097	0,416
V	28	-0,067	0,737	72	-0,126	0,290
W	28	0,127	0,521	72	-0,102	0,395
Y	28	0,252	0,196	72	-0,133	0,267
Yb	28	ND		72	-0,134	0,260
Zn	28	-0,134	0,496	72	0,024	0,840

Table A9. Pearson correlation between the concentrations of 38 and 48 elements in nestlings blood (n=35) and nestlings feathers (n=61), respectively, and the amount of agricultural land within each habitats in m^2. Significant correlations and p-values are bold.

	nestlings blood - agriculture			nestlings feathers - agriculture		
	n	r	*p*	*n*	r	*p*
Al	35	-0,016	0,927	61	0,085	0,517
As	35	0,293	0,087	61	0,149	0,251
Au	35	0,152	0,384	61	-0,182	0,160
B	35	0,091	0,603	61	0,248	0,054
Ba	35	-0,019	0,914	61	0,112	0,391
Bi	35	ND		61	-0,194	0,133
Ca	35	-0,098	0,575	61	-0,127	0,328
Cd	35	0,074	0,672	61	ND	
Ce	35	-0,117	0,503	61	0,239	0,063
Co	35	0,049	0,782	61	0,141	0,277
Cr	35	0,031	0,861	61	-0,030	0,821
Cs	35	**-0,392**	**0,020**	61	-0,234	0,069
Cu	35	-0,102	0,561	61	0,248	0,054
Dy	35	ND		61	0,159	0,220
Er	35	ND		61	0,139	0,287
Fe	35	-0,192	0,270	61	0,013	0,921
Gd	35	-0,094	0,590	61	ND	
Hg	35	-0,313	0,068	61	**-0,318**	**0,012**
Ho	35	ND		61	0,090	0,492
K	35	-0,154	0,378	61	-0,153	0,239
La	35	ND		61	0,235	0,068
Li	35	0,145	0,405	61	**0,289**	**0,024**
Mg	35	-0,187	0,283	61	-0,198	0,127
Mn	35	-0,058	0,742	61	**-0,283**	**0,027**
Mo	35	-0,073	0,678	61	-0,044	0,738
Na	35	0,139	0,425	61	-0,151	0,244
Nd	35	-0,031	0,859	61	**0,253**	**0,049**
Ni	35	0,081	0,644	61	-0,104	0,423
P	35	-0,169	0,331	61	-0,061	0,640
Pb	35	0,110	0,530	61	0,028	0,833
Pr	35	ND		61	**0,259**	**0,044**
Rb	35	**-0,587**	**<0,0005**	61	-0,222	0,085
S	35	0,014	0,938	61	-0,003	0,979
Sb	35	ND		61	**0,439**	**<0,0005**
Sc	35	ND		61	0,008	0,950
Se	35	0,018	0,919	61	0,168	0,194
Si	35	-0,015	0,934	61	-0,029	0,823
Sm	35	ND		61	0,188	0,147
Sn	35	0,097	0,579	61	0,230	0,074
Sr	35	-0,305	0,075	61	-0,219	0,089
Tb	35	ND		61	0,117	0,371
Th	35	-0,024	0,893	61	0,052	0,690
Ti	35	-0,206	0,236	61	-0,058	0,656
Tl	35	-0,050	0,777	61	**-0,330**	**<0,01**
U	35	0,088	0,615	61	0,064	0,624
V	35	-0,202	0,245	61	-0,053	0,685
W	35	ND		61	-0,006	0,962
Y	35	-0,107	0,539	61	0,178	0,169
Yb	35	ND		61	0,201	0,120
Zn	35	-0,168	0,334	61	-0,012	0,930

Table A10. shows a Pearson correlation between the concentrations of 41 and 52 elements in adults blood (n=28) and adults feathers (n=72), respectively, and the amount of forest within each habitats in m^2. Significant correlations and p-values are bold.

	adults blood - forest			adults feathers - forest		
	n	r	*p*	*n*	r	*p*
Ag	28	ND		72	-0,164	0,169
Al	28	0,154	0,434	72	0,120	0,313
As	28	-0,045	0,821	72	-0,145	0,226
Au	28	-0,094	0,633	72	-0,196	0,098
B	28	0,024	0,902	72	0,047	0,696
Ba	28	0,180	0,360	72	0,104	0,384
Bi	28	ND		72	0,046	0,702
Ca	28	0,017	0,931	72	-0,146	0,221
Cd	28	0,093	0,636	72	-0,172	0,149
Ce	28	-0,119	0,547	72	0,136	0,255
Co	28	**-0,383**	**0,044**	72	0,077	0,522
Cr	28	-0,283	0,144	72	0,173	0,146
Cs	28	0,626	3,7E-04	72	0,137	0,250
Cu	28	-0,037	0,851	72	-0,116	0,331
Dy	28	ND		72	0,106	0,376
Er	28	ND		72	0,122	0,309
Fe	28	0,129	0,514	72	0,094	0,430
Ga	28	ND		72	0,122	0,306
Gd	28	-0,053	0,788	72	ND	
Hf	28	ND		72	0,114	0,342
Hg	28	0,035	0,860	72	**0,297**	**0,011**
Ho	28	ND		72	0,117	0,327
K	28	-0,069	0,727	72	0,098	0,411
La	28	-0,115	0,559	72	0,132	0,268
Li	28	-0,299	0,122	72	ND	
Lu	28	ND		72	0,117	0,329
Mg	28	-0,104	0,597	72	0,048	0,687
Mn	28	0,118	0,549	72	0,029	0,812
Mo	28	-0,058	0,769	72	-0,076	0,526
Na	28	-0,051	0,797	72	0,074	0,540
Nd	28	-0,101	0,610	72	0,130	0,277
Ni	28	-0,284	0,143	72	0,024	0,839
P	28	0,001	0,997	72	0,036	0,765
Pb	28	-0,020	0,919	72	-0,140	0,240
Pr	28	ND		72	0,134	0,263
Rb	28	**0,428**	**0,023**	72	0,129	0,279
S	28	0,041	0,838	72	0,130	0,276
Sb	28	ND		72	**-0,234**	**0,048**
Sc	28	ND		72	0,096	0,424
Se	28	0,129	0,514	72	0,160	0,180
Si	28	-0,051	0,797	72	0,111	0,353
Sm	28	-0,171	0,384	72	0,129	0,281
Sn	28	ND		72	-0,137	0,252
Sr	28	0,056	0,778	72	0,059	0,623
Tb	28	ND		72	0,112	0,349
Th	28	-0,110	0,577	72	0,125	0,294
Ti	28	-0,146	0,460	72	0,149	0,213
Tl	28	-0,196	0,318	72	0,044	0,713
U	28	-0,052	0,793	72	0,094	0,432
V	28	-0,220	0,260	72	0,105	0,381
W	28	-0,103	0,602	72	0,210	0,077
Y	28	-0,131	0,508	72	0,119	0,319
Yb	28	ND		72	0,120	0,316
Zn	28	-0,003	0,987	72	-0,072	0,547

Table A11. Pearson correlation between the concentrations of 38 and 48 elements in nestlings blood (n=35) and nestlings feathers (n=61), respectively, and the amount of forest within each habitats in m^2. Significant correlations and p-values are bold.

	nestlings blood - forest			nestlings feathers - forest		
	n	r	*p*	*n*	**r**	*p*
Al	35	0,144	0,408	61	-0,161	0,216
As	35	-0,121	0,488	61	-0,142	0,277
Au	35	-0,062	0,725	61	0,114	0,381
B	35	-0,033	0,850	61	-0,052	0,690
Ba	35	0,055	0,754	61	-0,063	0,630
Bi	35	ND		61	-0,008	0,952
Ca	35	-0,053	0,762	61	-0,030	0,818
Cd	35	0,073	0,675	61	ND	
Ce	35	**0,356**	**0,036**	61	-0,202	0,119
Co	35	-0,115	0,509	61	-0,222	0,086
Cr	35	0,126	0,469	61	0,108	0,406
Cs	35	**0,437**	**<0,01**	61	**0,296**	**0,021**
Cu	35	-0,171	0,325	61	-0,185	0,153
Dy	35	ND		61	-0,157	0,226
Er	35	ND		61	-0,144	0,269
Fe	35	0,143	0,411	61	-0,116	0,374
Gd	35	**0,342**	**0,045**	61	ND	
Hg	35	0,042	0,809	61	0,103	0,430
Ho	35	ND		61	-0,094	0,471
K	35	0,122	0,487	61	0,159	0,222
La	35	ND		61	-0,175	0,177
Li	35	-0,018	0,920	61	-0,153	0,239
Mg	35	0,091	0,603	61	0,025	0,851
Mn	35	0,106	0,544	61	0,125	0,337
Mo	35	0,199	0,251	61	-0,007	0,959
Na	35	-0,106	0,544	61	0,169	0,193
Nd	35	0,294	0,086	61	-0,217	0,094
Ni	35	-0,004	0,980	61	0,090	0,490
P	35	0,106	0,544	61	0,051	0,694
Pb	35	-0,119	0,495	61	-0,036	0,786
Pr	35	ND		61	-0,198	0,126
Rb	35	**0,497**	**<0,01**	61	0,207	0,109
S	35	-0,028	0,873	61	0,075	0,564
Sb	35	ND		61	-0,145	0,266
Sc	35	ND		61	-0,052	0,693
Se	35	0,062	0,724	61	0,021	0,871
Si	35	0,186	0,285	61	0,057	0,662
Sm	35	ND		61	-0,165	0,203
Sn	35	-0,053	0,761	61	-0,168	0,196
Sr	35	0,275	0,110	61	0,104	0,426
Tb	35	ND		61	-0,068	0,603
Th	35	0,101	0,566	61	0,040	0,761
Ti	35	**0,444**	**<0,01**	61	0,016	0,903
Tl	35	0,286	0,096	61	0,176	0,176
U	35	-0,045	0,796	61	0,065	0,620
V	35	0,287	0,094	61	-0,107	0,413
W	35	ND		61	0,062	0,635
Y	35	-0,094	0,590	61	-0,171	0,187
Yb	35	ND		61	-0,216	0,094
Zn	35	0,153	0,381	61	-0,049	0,708

Table A12. Pearson correlation between the concentrations of 41 and 52 elements in adults blood (n=28) and adults feathers (n=72), respectively, and the amount of freshwater within each habitats in m^2. Significant correlations and p-values are bold.

	Adults blood - freshwater			Adults feathers - freshwater		
	n	r	*p*	*n*	r	*p*
Ag				72	-0,038	0,749
Al	28	-0,046	0,816	72	**0,242**	**0,041**
As	28	-0,172	0,382	72	-0,024	0,844
Au	28	-0,070	0,725	72	0,054	0,651
B	28	-0,147	0,456	72	-0,160	0,179
Ba	28	0,366	0,055	72	0,226	0,057
Bi	28	ND		72	-0,039	0,742
Ca	28	0,177	0,369	72	0,050	0,680
Cd	28	-0,131	0,505	72	-0,079	0,508
Ce	28	-0,061	0,759	72	0,231	0,051
Co	28	-0,040	0,839	72	**0,397**	**<0,001**
Cr	28	-0,004	0,985	72	0,200	0,093
Cs	28	0,016	0,934	72	0,204	0,086
Cu	28	0,136	0,490	72	-0,040	0,736
Dy	28	ND		72	**0,238**	**0,044**
Er	28	ND		72	**0,242**	**0,040**
Fe	28	0,170	0,387	72	**0,250**	**0,034**
Ga	28	ND		72	**0,249**	**0,035**
Gd	28	-0,080	0,686	72	ND	
Hf	28	ND		72	**0,280**	**0,017**
Hg	28	**0,622**	**<0,001**	72	0,216	0,068
Ho	28	ND		72	**0,241**	**0,042**
K	28	0,195	0,320	72	0,221	0,062
La	28	-0,071	0,721	72	**0,241**	**0,042**
Li	28	0,152	0,441	72	ND	
Lu	28	ND		72	**0,246**	**0,037**
Mg	28	0,196	0,317	72	0,205	0,085
Mn	28	0,128	0,515	72	0,158	0,185
Mo	28	0,059	0,766	72	-0,078	0,515
Na	28	-0,215	0,272	72	0,164	0,169
Nd	28	-0,072	0,718	72	**0,238**	**0,044**
Ni	28	0,005	0,979	72	0,155	0,192
P	28	0,255	0,191	72	0,198	0,095
Pb	28	**0,577**	**0,001**	72	0,004	0,972
Pr	28	ND		72	**0,240**	**0,042**
Rb	28	0,013	0,948	72	0,208	0,079
S	28	-0,008	0,966	72	-0,115	0,336
Sb	28	ND		72	0,017	0,887
Sc	28	ND		72	**0,281**	**0,017**
Se	28	0,108	0,583	72	0,014	0,908
Si	28	-0,028	0,889	72	**0,240**	**0,042**
Sm	28	-0,005	0,978	72	**0,233**	**0,049**
Sn	28	ND		72	0,052	0,662
Sr	28	0,001	0,997	72	**0,249**	**0,035**
Tb	28	ND		72	**0,243**	**0,039**
Th	28	-0,051	0,796	72	**0,256**	**0,030**
Ti	28	-0,054	0,786	72	**0,242**	**0,041**
Tl	28	0,049	0,806	72	0,041	0,731
U	28	-0,087	0,661	72	**0,244**	**0,039**
V	28	**0,586**	**0,001**	72	**0,261**	**0,027**
W	28	0,038	0,847	72	0,012	0,923
Y	28	-0,074	0,709	72	**0,243**	**0,040**
Yb	28	ND		72	**0,245**	**0,038**
Zn	28	0,240	0,219	72	-0,166	0,164

Table A13. Pearson correlation between the concentrations of 38 and 48 elements in nestlings blood (n=35) and nestlings feathers (n=61), respectively, and the amount of freshwater within each habitats in m^2. Significant correlations and p-values are bold.

	nestlings blood - freshwater			nestlings feathers - freshwater		
	n	r	*p*	*n*	r	*p*
Al	35	0,170	0,330	61	0,005	0,970
As	35	-0,064	0,716	61	-0,097	0,456
Au	35	0,168	0,334	61	**0,281**	**0,028**
B	35	0,231	0,181	61	-0,133	0,308
Ba	35	0,196	0,260	61	0,050	0,702
Bi	35	ND		61	0,113	0,386
Ca	35	-0,129	0,460	61	-0,003	0,980
Cd	35	-0,106	0,545	61	ND	
Ce	35	-0,040	0,819	61	0,093	0,477
Co	35	-0,239	0,166	61	-0,114	0,381
Cr	35	0,054	0,759	61	-0,090	0,492
Cs	35	-0,074	0,672	61	-0,098	0,452
Cu	35	-0,107	0,542	61	0,116	0,374
Dy	35	ND		61	-0,040	0,761
Er	35	ND		61	-0,025	0,848
Fe	35	-0,171	0,327	61	-0,045	0,730
Gd	35	0,051	0,773	61	ND	
Hg	35	-0,089	0,611	61	**0,286**	**0,026**
Ho	35	ND		61	-0,014	0,915
K	35	-0,169	0,331	61	0,006	0,964
La	35	ND		61	0,028	0,830
Li	35	-0,054	0,760	61	**-0,270**	**0,036**
Mg	35	-0,135	0,439	61	0,046	0,728
Mn	35	0,067	0,701	61	-0,091	0,488
Mo	35	-0,330	0,053	61	-0,033	0,803
Na	35	0,241	0,163	61	-0,004	0,974
Nd	35	-0,138	0,429	61	0,070	0,592
Ni	35	0,203	0,242	61	-0,014	0,915
P	35	-0,130	0,457	61	-0,172	0,184
Pb	35	-0,056	0,748	61	-0,008	0,950
Pr	35	ND		61	0,061	0,640
Rb	35	-0,127	0,468	61	-0,037	0,778
S	35	0,311	0,069	61	**-0,289**	**0,024**
Sb	35	ND		61	-0,202	0,118
Sc	35	ND		61	0,086	0,508
Se	35	0,129	0,460	61	0,184	0,155
Si	35	-0,008	0,966	61	-0,077	0,554
Sm	35	ND		61	-0,020	0,881
Sn	35	0,177	0,310	61	0,032	0,806
Sr	35	-0,034	0,844	61	-0,122	0,349
Tb	35	ND		61	-0,024	0,856
Th	35	0,248	0,150	61	0,037	0,779
Ti	35	-0,048	0,783	61	-0,069	0,597
Tl	35	0,167	0,338	61	**0,324**	**0,011**
U	35	0,259	0,133	61	-0,063	0,628
V	35	-0,058	0,740	61	-0,054	0,682
W	35	ND		61	-0,120	0,357
Y	35	**0,652**	**<0,0001**	61	-0,036	0,783
Yb	35	ND		61	-0,018	0,891
Zn	35	-0,124	0,478	61	0,037	0,775

Table A14. Pearson correlation between the concentrations of 41 and 52 elements in adults blood (n=28) and adults feathers (n=72), respectively, and the distance to roads from the nest box in m. Significant correlations and p-values are bold.

	Adults blood - distance to roads (m)			Adults feathers - distance to roads (m)		
	n	r	*p*	*n*	r	*p*
Ag	28	ND		72	-0,054	0,656
Al	28	0,063	0,750	72	-0,078	0,517
As	28	-0,058	0,770	72	0,032	0,791
Au	28	-0,055	0,781	72	0,048	0,692
B	28	-0,105	0,596	72	0,006	0,959
Ba	28	0,141	0,475	72	-0,057	0,636
Bi	28	ND		72	0,136	0,256
Ca	28	0,130	0,510	72	-0,092	0,442
Cd	28	0,118	0,551	72	0,146	0,222
Ce	28	0,023	0,908	72	-0,070	0,559
Co	28	-0,012	0,952	72	-0,122	0,308
Cr	28	0,154	0,434	72	-0,039	0,746
Cs	28	-0,026	0,895	72	-0,083	0,491
Cu	28	0,108	0,586	72	-0,048	0,690
Dy	28	ND		72	-0,073	0,542
Er	28	ND		72	-0,066	0,581
Fe	28	0,104	0,599	72	-0,081	0,497
Ga	28	ND		72	-0,085	0,479
Gd	28	0,149	0,448	72	ND	
Hf	28	ND		72	-0,071	0,552
Hg	28	0,099	0,617	72	0,141	0,238
Ho	28	ND		72	-0,074	0,536
K	28	0,148	0,453	72	-0,084	0,484
La	28	0,028	0,889	72	-0,070	0,557
Li	28	0,132	0,503	72	ND	
Lu	28	ND		72	-0,077	0,518
Mg	28	0,133	0,501	72	-0,101	0,401
Mn	28	0,060	0,761	72	0,035	0,768
Mo	28	0,158	0,421	72	-0,070	0,557
Na	28	-0,078	0,693	72	-0,071	0,555
Nd	28	0,008	0,967	72	-0,076	0,527
Ni	28	0,132	0,504	72	-0,064	0,592
P	28	0,095	0,631	72	-0,054	0,653
Pb	28	0,041	0,836	72	-0,094	0,431
Pr	28	ND		72	-0,076	0,526
Rb	28	0,225	0,250	72	-0,063	0,600
S	28	-0,010	0,958	72	0,040	0,737
Sb	28	ND		72	0,062	0,607
Sc	28	ND		72	-0,081	0,498
Se	28	0,023	0,908	72	-0,029	0,807
Si	28	0,253	0,194	72	-0,066	0,583
Sm	28	-0,020	0,920	72	-0,075	0,532
Sn	28	ND		72	-0,103	0,389
Sr	28	0,093	0,638	72	-0,074	0,537
Tb		ND		72	-0,075	0,532
Th	28	-0,092	0,642	72	-0,073	0,540
Ti	28	-0,021	0,917	72	-0,075	0,530
Tl	28	0,108	0,585	72	-0,093	0,437
U	28	0,068	0,730	72	-0,092	0,441
V	28	0,133	0,500	72	-0,089	0,458
W	28	0,172	0,380	72	-0,062	0,608
Y	28	0,031	0,875	72	-0,067	0,574
Yb				72	-0,071	0,553
Zn	28	0,171	0,383	72	4,7E-04	0,997

Table A15. Pearson correlation between the concentrations of 38 and 48 elements in nestlings blood (n=35) and nestlings feathers (n=61), respectively, and the distance to roads from the nest box in m. Significant correlations and p-values are bold.

	Nestlings blood - distance to roads (m)			Nestlings feathers - distance to roads (m)		
	n	r	*p*	*n*	r	*p*
Al	35	-0,080	0,647	61	-0,212	0,101
As	35	-0,221	0,201	61	-0,074	0,570
Au	35	0,128	0,464	61	0,009	0,947
B	35	-0,068	0,700	61	-0,010	0,937
Ba	35	0,117	0,504	61	-0,044	0,736
Bi	35	ND		61	0,015	0,911
Ca	35	0,048	0,785	61	**0,343**	**0,007**
Cd	35	0,163	0,349	61	ND	
Ce	35	-0,054	0,760	61	-0,057	0,665
Co	35	0,206	0,235	61	-0,144	0,267
Cr	35	-0,176	0,312	61	-0,082	0,532
Cs	35	0,006	0,974	61	0,051	0,698
Cu	35	0,225	0,193	61	-0,023	0,859
Dy	35	ND		61	-0,242	0,060
Er	35	ND		61	**-0,317**	**0,013**
Fe	35	0,085	0,629	61	-0,197	0,128
Gd	35	0,171	0,325	61	ND	
Hg	35	0,206	0,236	61	**0,422**	**0,001**
Ho	35	ND		61	**-0,267**	**0,037**
K	35	0,115	0,512	61	0,106	0,416
La	35	ND		61	-0,019	0,884
Li	35	-0,007	0,970	61	0,082	0,532
Mg	35	0,172	0,322	61	**0,376**	**0,003**
Mn	35	0,054	0,760	61	**0,277**	**0,031**
Mo	35	**0,408**	**0,015**	61	-0,130	0,317
Na	35	-0,124	0,479	61	0,104	0,426
Nd	35	0,122	0,484	61	-0,145	0,265
Ni	35	0,070	0,690	61	0,007	0,960
P	35	0,085	0,626	61	0,108	0,409
Pb	35	-0,205	0,238	61	0,140	0,283
Pr	35	ND		61	-0,132	0,312
Rb	35	0,242	0,161	61	0,108	0,409
S	35	-0,003	0,985	61	-0,005	0,967
Sb	35	ND		61	-0,231	0,073
Sc	35	ND		61	0,085	0,513
Se	35	0,025	0,889	61	0,003	0,983
Si	35	-0,133	0,446	61	-0,053	0,688
Sm	35	ND		61	-0,186	0,152
Sn	35	0,103	0,556	61	-0,222	0,086
Sr	35	**0,371**	**0,028**	61	**0,407**	**0,001**
Tb	35	ND		61	-0,108	0,409
Th	35	-0,013	0,941	61	0,053	0,683
Ti	35	-0,041	0,817	61	-0,249	0,053
Tl	35	0,103	0,555	61	**0,470**	**<0,002**
U	35	-0,191	0,271	61	0,041	0,753
V	35	-0,086	0,622	61	-0,190	0,142
W	35	ND		61	0,070	0,593
Y	35	0,139	0,425	61	**-0,276**	**0,031**
Yb	35	ND		61	**-0,326**	**0,010**
Zn	35	0,190	0,274	61	0,220	0,089

Table A16. Pearson correlation between the concentrations of 41 and 52 elements in adults blood (n=28) and adults feathers (n=72), respectively, and the distance to industry from the nest box in m. Significant correlations and p-values are bold.

	Adults blood - distance to industry			Adults feathers - distance to industry		
	n	r	*p*	*n*	r	*p*
Ag	28	ND		72	-0,0866	0,469
Al	28	-0,23	0,239	72	0,107	0,373
As	28	0,126	0,523	72	0,183	0,123
Au	28	-0,169	0,391	72	-0,109	0,364
B	28	-0,13	0,51	72	0,0839	0,483
Ba	28	0,0595	0,763	72	0,126	0,292
Bi	28	ND		72	-0,23	0,0517
Ca	28	-0,186	0,344	72	0,061	0,611
Cd	28	-0,222	0,256	72	0,113	0,344
Ce	28	-0,289	0,136	72	0,112	0,348
Co	28	-0,38	0,0463	72	0,207	0,0813
Cr	28	-0,297	0,124	72	0,0701	0,559
Cs	28	-0,0197	0,921	72	0,138	0,247
Cu	28	-0,0496	0,802	72	0,00494	0,967
Dy	28	ND		72	0,101	0,398
Er	28	ND		72	0,102	0,395
Fe	28	0,298	0,124	72	0,106	0,375
Ga	28	ND		72	0,104	0,385
Gd	28	-0,295	0,127	72	ND	
Hf	28	ND		72	0,107	0,372
Hg	28	**0,505**	**0,0061**	72	0,229	0,0527
Ho	28	ND		72	0,108	0,367
K	28	0,088	0,656	72	0,105	0,381
La	28	-0,265	0,173	72	0,14	0,239
Li	28	-0,325	0,0913	72	ND	
Lu	28	ND		72	0,106	0,376
Mg	28	0,0359	0,856	72	0,117	0,327
Mn	28	-0,235	0,229	72	0,123	0,302
Mo	28	-0,0765	0,699	72	0,0654	0,585
Na	28	-0,264	0,175	72	0,0734	0,54
Nd	28	-0,288	0,137	72	0,138	0,249
Ni	28	-0,277	0,154	72	0,0824	0,491
P	28	0,209	0,285	72	0,157	0,188
Pb	28	0,169	0,389	72	-0,0773	0,519
Pr	28	ND		72	0,137	0,25
Rb	28	0,206	0,292	72	0,106	0,376
S	28	0,0103	0,958	72	-0,097	0,418
Sb	28	ND		72	-0,16	0,18
Sc	28	ND		72	0,0765	0,523
Se	28	0,325	0,092	72	0,116	0,333
Si	28	-0,14	0,478	72	0,0882	0,461
Sm	28	-0,23	0,239	72	0,131	0,272
Sn	28	ND		72	-0,09	0,452
Sr	28	-0,32	0,0974	72	0,115	0,337
Tb	28	ND		72	0,112	0,348
Th	28	-0,24	0,22	72	0,0883	0,461
Ti	28	-0,192	0,328	72	0,11	0,36
Tl	28	-0,15	0,447	72	0,156	0,192
U	28	-0,233	0,232	72	0,169	0,156
V	28	0,13	0,51	72	0,11	0,36
W	28	-0,156	0,429	72	-0,143	0,23
Y	28	-0,231	0,236	72	0,104	0,387
Yb	28	ND		72	0,105	0,382
Zn	28	0,00935	0,962	72	0,0481	0,688

Table A17. Pearson correlation between the concentrations of 38 and 48 elements in nestlings blood (n=35) and nestlings feathers (n=61), respectively, and the distance to industry from the nest box in m. Significant correlations and p-values are bold.

	Nestlings blood - distance to industry			Nestlings feathers - distance to industry		
	n	r	*p*	*n*	r	*p*
Al	35	-0,110	0,530	61	0,179	0,167
As	35	-0,078	0,656	61	0,071	0,588
Au	35	0,047	0,787	61	**0,294**	**0,021**
B	35	-0,042	0,811	61	-0,195	0,133
Ba	35	0,156	0,371	61	-0,040	0,757
Bi	35	ND		61	**0,286**	**0,026**
Ca	35	0,068	0,696	61	-0,113	0,388
Cd	35	-0,209	0,229	61	ND	
Ce	35	-0,121	0,487	61	0,107	0,410
Co	35	0,054	0,757	61	0,082	0,529
Cr	35	-0,183	0,292	61	0,056	0,666
Cs	35	-0,207	0,232	61	-0,138	0,288
Cu	35	0,201	0,247	61	0,143	0,271
Dy	35	ND		61	0,046	0,724
Er	35	ND		61	0,077	0,555
Fe	35	0,035	0,843	61	0,157	0,227
Gd	35	-0,139	0,424	61	ND	
Hg	35	0,280	0,103	61	**0,351**	**0,006**
Ho	35	ND		61	0,105	0,420
K	35	-0,061	0,729	61	-0,106	0,415
La	35	ND		61	0,075	0,568
Li	35	-0,195	0,262	61	-0,130	0,317
Mg	35	-0,094	0,593	61	-0,143	0,270
Mn	35	-0,238	0,169	61	-0,082	0,531
Mo	35	-0,162	0,352	61	0,117	0,369
Na	35	0,006	0,971	61	-0,099	0,448
Nd	35	-0,094	0,593	61	0,076	0,563
Ni	35	-0,070	0,689	61	-0,021	0,874
P	35	-0,042	0,811	61	-0,082	0,532
Pb	35	-0,125	0,476	61	-0,070	0,593
Pr	35	ND		61	0,049	0,706
Rb	35	-0,213	0,220	61	-0,136	0,295
S	35	0,026	0,882	61	-0,033	0,801
Sb	35	ND		61	-0,087	0,503
Sc	35	ND		61	0,009	0,943
Se	35	0,140	0,423	61	0,157	0,228
Si	35	-0,050	0,775	61	-0,007	0,956
Sm	35	ND		61	0,074	0,569
Sn	35	-0,022	0,899	61	-0,046	0,726
Sr	35	**-0,354**	**0,037**	61	-0,224	0,082
Tb	35	ND		61	-0,016	0,900
Th	35	-0,115	0,511	61	-0,096	0,461
Ti	35	-0,261	0,130	61	**0,261**	**0,042**
Tl	35	-0,027	0,878	61	0,074	0,574
U	35	0,016	0,926	61	0,052	0,690
V	35	-0,075	0,668	61	0,242	0,061
W	35	ND		61	-0,059	0,651
Y	35	0,214	0,216	61	0,134	0,304
Yb	35	ND		61	0,057	0,664
Zn	35	-0,058	0,742	61	-0,130	0,318

Table A18. For adults and nestling in total: Sample number, relationship (2Ad=adult-2Ad1=nestling number one from adult number two), localities, municipalities, ring no., age, body mass, wing length (only for adults), sex, material analysed, number of eggs and nestlings (only for adults). In 2016 only adults were analysed.

Id-year	Relationship	Location	Municipality	Ringing no	Age	Sex	Bm	Wl	Material	Eggs	Nestling
72-17	18Ad1	Hammerodden	Levanger	3026484	J	M	325		Blood		
73-17	3ad4	Oladalen	Levanger	3026493	J	F	265		Blood		
74-17	9ad1	Asklund	Steinkjer	3057404	J	M	240		Blood		
75-17	4ad3	Floan	Levanger	3026495	J	F	200		Blood		
76-17	7ad2	Nessflata	Verdal	3026498	J	F	200		Blood		
77-17	13ad1	Heggstad	Verdal	3026500	J	F	255		Blood		
78-17	23Ad1	Vika	Verran	398477	J	F	305		Blood		
79-17	21Ad3	Brattreitåsen	Verran	398492	J	F	345		Blood		
80-17	26Ad1	Sandvika	Ytterøy-Levanger	3057425	J	M	265		Blood		
81-17	11ad3	Hoklingen2	Levanger	3026486	J	M	340		Blood		
82-17	2ad3	Halsan2 (Nesjan)	Levanger	3026490	J	M	245		Blood		
83-17	3ad1	Oladalen	Levanger	3026492	J	F	280		Blood		
84-17	4ad1	Floan	Levanger	3026496	J	M	255		Blood		
85-17	6Ad1	Vinne	Levanger	3026478	J	F	225		Blood		
86-17	10ad1	Lorås	Inderøy	3057408	J	M	320		Blood		
87-17	10Ad2	Lorås	Inderøy	3057407	J	M	295		Blood		
88-17	17Ad1	Lyngstad	Inderøy	3057406	J	M	270		Blood		
89-17	16Ad2	Hallset	Inderøy	3057410	J	F	350		Blood		
90-17	-	Bruåsen	Inderøy	3057411	J	F	350		Blood		
91-17	24Ad2	Møen	Ytterøy-Levanger	3057422	J	F	285		Blood		
92-17	25Ad2	Berghaugen	Ytterøy-Levanger	3057424	J	F	260		Blood		
93-17	1Ad	Daling (Ronglan)	Levanger	3026466	Ad	F	585	273	Blood	3	0
94-17	2Ad	Halsan2 (Nesjan)	Levanger	3026467	Ad	F	630	281	Blood	4	3
95-17	3Ad	Oladalen	Levanger	3026369	Ad	F	670	286	Blood	5	4
96-17	4Ad	Floan	Levanger	3012758	Ad	F	680	283	Blood	4	4
97-17	5Ad	Kloster Munkeby	Levanger	3026161	Ad	F	635	286	Blood	5	0
98-17	6Ad	Vinne	Verdal	3012582	Ad	F	635	-	Blood	5	5
99-17	7Ad	Nessflata	Verdal	3026185	Ad	F	590	290	Blood	4	2
100-17	9Ad	Asklund	Steinkjer	3012610	Ad	F	625	292	Blood	4	1
101-17	11Ad	Hoklingen2	Levanger	394012	Ad	F	585	282	Blood	4	3
102-17	12Ad	Heir	Levanger	3026367	Ad	F	605	281	Blood	6	0
103-17	13Ad	Heggstad	Verdal	3012695	Ad	F	620	290	Blood	4	4
104-17	16Ad	Hallset	Inderøy	3026464	Ad	F	580	278	Blood	4	2
43-18	101Ad	Hammerbukta	Levanger	3026141	Ad	F	675	292	Blood	4	3
44-18	103Ad	Oladalen	Levanger	3026369	Ad	F	680	289	Blood	4	3
45-18	104Ad	Munkeby1	Levanger	3057443	Ad	F	705	292	Blood	4	2
46-18	105Ad	Floan	Levanger	3057444	Ad	F	625	291	Blood	2	0
48-18	107Ad	Nesflata	Verdal	3026185	Ad	F	615	290	Blood	2	0
49-18	108Ad	Vinne kirke	Verdal	3012582	Ad	F	600	294	Blood	4	0
50-18	109Ad	Vanntårn Mos.	Inderøy	3026368	Ad	F	640	300	Blood	4	4
51-18	110Ad	Gipling-Kleiva	Inderøy	3026173	Ad	F	675	277	Blood	3	3
52-18	111Ad	Letnes	Inderøy	3057446	Ad	F	585	289	Blood	3	0
53-18	112Ad	Lorås	Inderøy	3057447	Ad	F	680	286	Blood	3	3
54-18	113Ad	Hegstad	Verdal	3012695	Ad	F	630	295	Blood	4	4
55-18	114Ad	Sende	Verdal	3026164	Ad	F	-	288	Blood	3	3
56-18	115Ad	Lyngstad	Inderøy	3026465	Ad	F	620	280	Blood	3	0

Id-year	Relationship	Location	Municipality	Ring	Age	Sex	Bm	Wl	Material	Eggs	Nestling
57-18	116Ad	Kringla	Steinkjer	3012518	Ad	F	630	289	Blood	3	2
58-18	118Ad	Asklund	Steinkjer	3012610	Ad	F	625	295	Blood	3	2
59-18	119Ad	Buås/Oppem	Steinkjer	3057449	Ad	F	670	298	Blood	3	3
61-18	103Ad1	Oladalen juv.	Levanger	3057459	J	F	325		Blood		
62-18	104Ad1	Munkeby1 juv.	Levanger	3057455	J	M	275		Blood		
63-18	109Ad1	Vanntårn Mos.	Inderøy	3057505	J	M	355		Blood		
64-18	110Ad1	Gipling-Kleiva	Inderøy	3057465	J	F	-		Blood		
65-18	112Ad1	Lorås	Inderøy	3057472	J	F	340		Blood		
66-18	113Ad2	Hegstad	Verdal	3057477	J	F	395		Blood		
67-18	114Ad2	Sende	Verdal	3057481	J	M	335		Blood		
68-18	116Ad1	Kringla	Steinkjer	3057471	J	F	335		Blood		
69-18	117Ad1	Reitan	Verdal	3057483	J	M	325		Blood		
70-18	118Ad1	Asklund	Steinkjer	3057468	J	F	320		Blood		
71-18	119Ad1	Buås/Oppem	Steinkjer	3057462	J	F	380		Blood		
72-18	119Ad3	Buås/Oppem	Steinkjer	3057464	J	M	325		Blood		
73-18	120Ad1	Brattreitåsen	Verran	398497	J	F	305		Blood		
74-18	127Ad1	Hello	Verdal	3057475	J	M	290		Blood		
1-16	-	Vanntårn-Mos.	Inderøy	3026368	Ad	F	610	295	Feathers	3	2
2-16	-	Movatnet	Levanger	321690	Ad	F	-	299	Feathers	3	3
3-16	-	Lundskin	Verdal	3026366	Ad	F	-	293	Feathers	3	3
4-16	-	Floan	Levanger	3012758	Ad	F	625	289	Feathers	3	3
5-16	-	Heir	Levanger	3026367	Ad	F	-	286	Feathers	3	3
6-16	-	Munkeby2	Levanger	3012782	Ad	F	680	286	Feathers	3	2
7-16	-	Brattreitåsen	Verran	3012624	Ad	F	570	299	Feathers	3	3
8-16	-	Blomseth	Verran	3026370	Ad	F	700	292	Feathers	2	2
9-16	-	Tunsdalen	Verran	3012721	Ad	F	610		Feathers	4	2
10-16	-	Møen	Ytterøy-Levanger	3012508	Ad	F	-		Feathers	3	2
11-16	-	Hall	Inderøy	3026364	Ad	F	600	293	Feathers	5	1
12-16	-	Bråtte	Inderøy	3026308	Ad	F	600	285	Feathers	3	3
13-16	-	Lorvik	Steinkjer	3026339	Ad	F	610	301	Feathers	3	0
14-16	-	Oladalen	Levanger	3026369	Ad	F	590	286	Feathers	2	0
15-16	-	Mjøsund	Levanger	3026371	Ad	F	680	283	Feathers	3	0
16-16	-	Manem	Inderøy	3026365	Ad	F	585	286	Feathers	3	2
17a-16	-	Leklemsåsen	Verdal	3012665	Ad	F	515	282	Feathers	3	1
17b-16	-	Leklemsåsen	Verdal	3012665	Ad	F	515	282	Feathers	3	1
18-16	-	Hello	Verdal	3012693	Ad	F	590	284	Feathers	3	3
19-16	-	Vinne	Verdal	3012582	Ad	F	555	280	Feathers	3	3
1-17	14Ad	Vanntårn Mos.	Inderøy	3026368	Ad	F	625	-	Feathers	4	4
2-17	15Ad	Aunet Mos.	Inderøy	3026173	Ad	F	620	-	Feathers	5	0
3-17	16Ad	Hallset	Inderøy	3026464	Ad	F	580	278	Feathers	4	2
4-17	17Ad	Lyngstad	Inderøy	3026465	Ad	F	600	292	Feathers	4	1
5-17	18Ad	Hammerodden	Levanger	3026141	Ad	F	680	-	Feathers	4	2
6-17	1Ad	Daling (Ronglan)	Levanger	3026466	Ad	F	585	273	Feathers	3	0
7-17	19Ad	Mjøsund	Levanger	3026371	Ad	F	670	282	Feathers	3	0
8-17	2Ad	Halsan2 (Nesjan)	Levanger	3026467	Ad	F	630	281	Feathers	4	3
9-17	3Ad	Oladalen	Levanger	3026369	Ad	F	670	286	Feathers	5	4
10-17	4Ad	Floan	Levanger	3012758	Ad	F	680	283	Feathers	4	4
11-17	5Ad	Kloster Munkeby	Levanger	3026161	Ad	F	635	286	Feathers	5	0
12-17	6Ad	Vinne	Verdal	3012582	Ad	F	635	-	Feathers	5	5
13-17	7Ad	Nessflata	Verdal	3026185	Ad	F	590	290	Feathers	4	2

Id-year	Relationship	Location	Municipality	Ring	Age	Sex	Bm	Wl	Material	Eggs	Nestling
14-17	8Ad	Vibesåsen	Steinkjer	3026469	Ad	F	480	286	Feathers	3	1
15-17	9Ad	Asklund	Steinkjer	3012610	Ad	F	625	292	Feathers	4	1
16-17	20Ad	Hall	Inderøy	3026468	Ad	F	550	281	Feathers	4	0
17-17	21Ad	Brattreitåsen	Verran	3026470	Ad	F	625	276	Feathers	4	4
18-17	22Ad	Tunsdalen (Tua)	Verran	3012721	Ad	F	735	289	Feathers	4	0
19-17	23Ad	Vika	Verran	3026471	Ad	F	-	282	Feathers	4	3
20-17	10Ad	Lorås	Inderøy	3026473	Ad	F	615	283	Feathers	2	2
21-17	11Ad	Hoklingen2	Levanger	394012	Ad	F	585	282	Feathers	4	3
22-17	12Ad	Heir	Levanger	3026367	Ad	F	605	281	Feathers	6	0
23-17	13Ad	Hegstad	Verdal	3012695	Ad	F	620	290	Feathers	4	4
24-17	24Ad	Møen	Ytterøy-Levanger	3012508	Ad	F	610	290	Feathers	3	2
25-17	25Ad	Berghaugen	Ytterøy-Levanger	3026474	Ad	F	585	292	Feathers	3	2
26-17	26Ad	Sandvika	Ytterøy-Levanger	3026329	Ad	F	590	294	Feathers	3	2
27-17	18Ad1	Hammerodden	Levanger	3026484	J	M	325		Feathers		
28-17	18Ad2	Hammerodden	Levanger	3026483	J	M	310		Feathers		
29-17	11Ad1	Hoklingen2	Levanger	3026485	J	M	290		Feathers		
30-17	11Ad2	Hoklingen2	Levanger	3026487	J	M	335		Feathers		
31-17	11Ad3	Hoklingen2	Levanger	3026486	J	M	340		Feathers		
32-17	2Ad1	Halsan2 (Nesjan)	Levanger	3026488	J	F	235		Feathers		
33-17	2Ad2	Halsan2 (Nesjan)	Levanger	3026489	J	M	180		Feathers		
34-17	2Ad3	Halsan2 (Nesjan)	Levanger	3026490	J	M	245		Feathers		
35-17	3Ad1	Oladalen	Levanger	3026492	J	F	280		Feathers		
36-17	3Ad3	Oladalen	Levanger	3026494	J	M	270		Feathers		
37-17	3Ad4	Oladalen	Levanger	3026493	J	F	265		Feathers		
38-17	4Ad1	Floan	Levanger	3026496	J	M	255		Feathers		
39-17	4Ad2	Floan	Levanger	3026497	J	F	250		Feathers		
40-17	4Ad3	Floan	Levanger	3026495	J	F	200		Feathers		
41-17	6Ad1	Vinne	Verdal	3026478	J	F	225		Feathers		
42-17	6Ad2	Vinne	Verdal	3026475	J	M	195		Feathers		
43-17	6Ad3	Vinne	Verdal	3026476	J	F	205		Feathers		
44-17	6Ad4	Vinne	Verdal	3026479	J	F	220		Feathers		
45-17	13Ad1	Heggstad	Verdal	3026500	J	F	255		Feathers		
46-17	13Ad2	Heggstad	Verdal	3057401	J	F	255		Feathers		
47-17	13Ad4	Heggstad	Verdal	3057403	J	F	225		Feathers		
48-17	9Ad1	Asklund	Steinkjer	3057404	J	M	240		Feathers		
49-17	8Ad2	Vibesåsen	Steinkjer	3057432	J	F	240		Feathers		
50-17	10Ad1	Lorås	Inderøy	3057408	J	M	320		Feathers		
51-17	10Ad2	Lorås	Inderøy	3057407	J	M	295		Feathers		
52-17	17Ad1	Lyngstad	Inderøy	3057406	J	M	270		Feathers		
53-17	16Ad1	Hallset	Inderøy	3057409	J	M	305		Feathers		
54-17	16Ad2	Hallset	Inderøy	3057410	J	F	350		Feathers		
55-17	-	Bruåsen	Inderøy	3057411	J	F	350		Feathers		
56-17	-	Bruåsen	Inderøy	3057412	J	F	345		Feathers		
57-17	-	Bruåsen	Inderøy	3057413	J	M	315		Feathers		
58-17	-	Bruåsen	Inderøy	3057414	J	M	320		Feathers		
59-17	24Ad1	Møen	Ytterøy-Levanger	3057421	J	M	260		Feathers		
60-17	24Ad2	Møen	Ytterøy-Levanger	3057422	J	F	285		Feathers		
61-17	25Ad1	Berghaugen	Ytterøy-Levanger	3057423	J	F	200		Feathers		
62-17	25Ad2	Berghaugen	Ytterøy-Levanger	3057424	J	F	260		Feathers		
63-17	26Ad1	Sandvika	Ytterøy-Levanger	3057425	J	M	265		Feathers		

Id-year	Relationship	Location	Municipality	Ring	Age	Sex	Bm	Wl	Material	Eggs	Nestling
64-17	26Ad2	Sandvika	Ytterøy-Levanger	3057426	J	M	220		Feathers		
65-17	21Ad1	Brattreitåsen	Verran	398490	J	M	290		Feathers		
66-17	21Ad2	Brattreitåsen	Verran	398491	J	M	310		Feathers		
67-17	21Ad3	Brattreitåsen	Verran	398492	J	F	345		Feathers		
68-17	21Ad4	Brattreitåsen	Verran	398493	J	F	290		Feathers		
69-17	23Ad1	Vika	Verran	398477	J	F	305		Feathers		
70-17	23Ad2	Vika	Verran	398478	J	M	300		Feathers		
71-17	23Ad3	Vika	Verran	398489	J	M	235		Feathers		
1-18	101Ad	Hammerbukta	Levanger	3026141	Ad	F	675	292	Feathers	4	3
2-18	102Ad	Mjøsund	Levanger	3026371	Ad	F	655	282	Feathers	4	3
3-18	103Ad	Oladalen	Levanger	3026369	Ad	F	680	289	Feathers	4	3
4-18	104Ad	Munkeby1	Levanger	3057443	Ad	F	705	292	Feathers	4	2
5-18	105Ad	Floan	Levanger	3057444	Ad	F	625	291	Feathers	2	0
6-18	106Ad	Lyngbakken	Levanger	3057445	Ad	F	560	285	Feathers	2	0
7-18	107Ad	Nessflata	Verdal	3026185	Ad	F	615	290	Feathers	2	0
8-18	108Ad	Vinne kirke	Verdal	3012582	Ad	F	600	294	Feathers	4	0
9-18	109Ad	Vanntårn Mos.	Inderøy	3026368	Ad	F	640	300	Feathers	4	4
10-18	110Ad	Gipling-Kleiva	Inderøy	3026173	Ad	F	675	277	Feathers	3	3
11-18	111Ad	Letnes	Inderøy	3057446	Ad	F	585	289	Feathers	3	0
12-18	112Ad	Lorås	Inderøy	3057447	Ad	F	680	286	Feathers	3	3
13-18	113Ad	Heggstad	Verdal	3012695	Ad	F	630	295	Feathers	4	4
14-18	114Ad	Sende	Verdal	3026164	Ad	F	-	288	Feathers	3	3
15-18	115Ad	Lyngstad	Inderøy	3026465	Ad	F	620	280	Feathers	3	0
16-18	116Ad	Kringla	Steinkjer	3012518	Ad	F	630	289	Feathers	3	2
17-18	117Ad	Reitan	Verdal	3057448	Ad	F	680	299	Feathers	4	2
18-18	118Ad	Asklund	Steinkjer	3012610	Ad	F	625	295	Feathers	3	2
19-18	119Ad	Oppem	Steinkjer	3057449	Ad	F	670	298	Feathers	3	3
20-18	120Ad	Brattreitåsen	Verran	3026471	Ad	F	600	-	Feathers	3	2
21-18	121Ad	Skjevik	Steinkjer	3057450	Ad	F	625	292	Feathers	4	3
22-18	122Ad	Nordvik	Ytterøy-Levanger	3026168	Ad	F	580	-	Feathers	3	1
23-18	123Ad	Møen	Ytterøy-Levanger	3012508	Ad	F	620	-	Feathers	2	2
24-18	124Ad	Sandvika	Ytterøy-Levanger	3026329	Ad	F	650	-	Feathers	4	4
25-18	125Ad	Tua - Tunsdalen	Verran	3012721	Ad	F	740	-	Feathers	4	3
26-18	126Ad	Storholmen	Verdal	3057436	Ad	F	650	-	Feathers	4	2
27-18	101Ad1	Hammerbukta	Levanger	3026456	J	F	330		Feathers		
28-18	103Ad1	Oladalen	Levanger	3057459	J	F	325		Feathers		
29-18	104Ad1	Munkeby1	Levanger	3057455	J	M	275		Feathers		
30-18	127Ad1	Hello juv.	Verdal	3057475	J	M	290		Feathers		
31-18	110Ad1	Gipling-Kleiva	Inderøy	3057465	J	F	-		Feathers		
32-18	112Ad1	Lorås	Inderøy	3057472	J	F	340		Feathers		
33-18	113Ad2	Heggstad	Verdal	3057477	J	F	395		Feathers		
34-18	114Ad2	Sende	Verdal	3057481	J	M	335		Feathers		
35-18	116Ad2	Kringla	Steinkjer	3057470	J	M	335		Feathers		
36-18	117Ad1	Reitan	Verdal	3057483	J	M	325		Feathers		
37-18	118Ad1	Asklund	Steinkjer	3057468	J	F	320		Feathers		
38-18	119Ad1	Buås/Oppem	Steinkjer	3057462	J	F	380		Feathers		
39-18	120Ad1	Brattreitåsen	Verran	398497	J	F	305		Feathers		
40-18	125Ad1	Tua	Verran	3057496	J		360		Feathers		
41-18	122Ad1	Verrastranda	Verran	3057498	J		335		Feathers		
42-18	109Ad1	Vanntårn-Mosvik	Inderøy	3057505	J	M	355		Feathers		

Table A19. Concentrations from all the samples (µg/g) from Al to Co. Empty cells means more than 50% of the concentrations were below LOD and discarded from the analysis.

id	Al	As	Au	B	Ba	Bi	Ca	Cd	Ce	Co
72-17	1,3239	0,0139	0,0003	0,9119	0,5002		20,2610	0,0003	0,0005	0,0041
73-17	1,4657	0,0162	0,0005	0,8701	0,1397		22,5103	0,0050	0,0004	0,0179
74-17	0,8328	0,0141	0,0004	0,4894	0,9234		32,6136	0,0041	0,0010	0,0107
75-17	0,6243	0,0098	0,0002	0,4380	0,1207		38,9259	0,0023	0,0003	0,0114
76-17	0,3255	0,0162	0,0002	0,2655	0,0631		45,8560	0,0005	0,0001	0,0302
77-17	0,1651	0,0062	0,0002	0,1526	0,0172		53,2691	0,0007	0,0001	0,0168
78-17	0,1512	0,0036	0,0002	0,1315	0,0580		52,7902	0,0002	0,0001	0,0070
79-17	0,1829	0,0054	0,0001	0,1587	0,1210		55,5058	0,0003	0,0001	0,0093
80-17	0,1621	0,0050	0,0001	0,1402	0,0237		54,5268	0,0001	0,0001	0,0252
81-17	0,1231	0,0041	0,0002	0,1030	0,0523		58,6445	0,0001	0,0000	0,0095
82-17	0,2121	0,0053	0,0002	0,1633	0,2228		50,9193	0,0004	0,0001	0,0164
83-17	0,2099	0,0083	0,0001	0,1513	0,1061		51,3942	0,0112	0,0002	0,0225
84-17	0,3182	0,0063	0,0002	0,2466	0,0850		50,8710	0,0005	0,0001	0,0103
85-17	0,2799	0,0141	0,0001	0,2124	0,0433		49,7800	0,0004	0,0001	0,0163
86-17	0,9248	0,0533	0,0004	0,7595	0,1423		30,0345	0,0057	0,0003	0,0052
87-17	0,7738	0,0114	0,0002	0,6136	0,4494		34,3277	0,0003	0,0004	0,0082
88-17	0,2997	0,0068	0,0001	0,1835	0,1242		50,0940	0,0003	0,0001	0,0148
89-17	0,5085	0,0135	0,0002	0,3510	0,2489		44,6829	0,0003	0,0002	0,0082
90-17	0,4048	0,0103	0,0002	0,2654	0,0949		42,8475	0,0003	0,0002	0,0053
91-17	0,1350	0,0046	0,0001	0,1293	0,0258		54,5505	0,0003	0,0000	0,0211
92-17	0,1435	0,0043	0,0001	0,1277	0,0322		57,7811	0,0010	0,0001	0,0291
93-17	0,3241	0,0067	0,0001	0,1882	0,0504		41,4321	0,0031	0,0002	0,0138
94-17	0,2313	0,0038	0,0001	0,1373	0,0766		34,7103	0,0012	0,0002	0,0077
95-17	0,4523	0,0056	0,0001	0,3612	0,2198		37,0687	0,0014	0,0003	0,0089
96-17	0,4080	0,0047	0,0002	0,3035	0,1118		39,6017	0,0011	0,0003	0,0095
97-17	0,2011	0,0038	0,0001	0,1364	0,0256		50,9866	0,0007	0,0002	0,0100
98-17	0,2446	0,0049	0,0002	0,1760	0,0304		45,6597	0,0004	0,0002	0,0260
99-17	0,4682	0,0069	0,0001	0,3867	0,0440		31,1724	0,0005	0,0002	0,0092
100-17	0,1581	0,0038	0,0001	0,0865	0,0208		52,9224	0,0017	0,0001	0,0152
101-17	0,5378	0,0038	0,0001	0,1173	0,0500		42,0570	0,0006	0,0003	0,0065
102-17	0,3299	0,0164	0,0001	0,2429	0,0704		41,4836	0,0002	0,0002	0,0257
103-17	0,1581	0,0038	0,0001	0,0430	0,0118		54,9429	0,0004	0,0003	0,0090
104-17	0,2047	0,0201	0,0001	0,1456	0,0473		39,8131	0,0003	0,0001	0,0054
43-18	0,2847	0,0087	0,0003	0,2956	0,4922		57,3325	0,0001	0,0002	0,0087
44-18	2,0416	0,0055	0,0004	0,2256	0,0449		43,0951	0,0004	0,0020	0,0067
45-18	16,4991	0,0368	0,0008	0,6950	0,2213		65,0582	0,0015	0,0109	0,0208
46-18	1,1931	0,0102	0,0003	0,2575	0,0662		66,2901	0,0001	0,0006	0,0073
48-18	3,0893	0,0084	0,0004	0,1785	0,0286		54,2963	0,0002	0,0020	0,0174
49-18	4,1908	0,0077	0,0004	0,3143	0,0412		49,6950	0,0001	0,0044	0,0207
50-18	0,7203	0,0128	0,0003	0,4154	0,2946		54,6573	0,0007	0,0017	0,0073
51-18	0,8940	0,0137	0,0004	0,4729	0,2104		32,4073	0,0001	0,0006	0,0037
52-18	0,2434	0,0052	0,0003	0,1970	0,0222		46,5149	0,0002	0,0002	0,0038
53-18	0,6890	0,0173	0,0002	0,6016	0,1957		18,7244	0,0001	0,0003	0,0027
54-18	0,5931	0,0056	0,0003	0,2592	0,0225		38,0158	0,0003	0,0005	0,0047
55-18	0,2502	0,0276	0,0003	0,2308	0,0780		41,0517	0,0002	0,0001	0,0078
56-18	0,5447	0,0134	0,0002	0,5110	0,0553		24,2812	0,0004	0,0003	0,0087
57-18	0,3732	0,0038	0,0002	0,1315	0,0884		51,0040	0,0004	0,0004	0,0024
58-18	0,4384	0,0110	0,0002	0,3589	0,2009		33,5751	0,0001	0,0002	0,0082
59-18	0,2977	0,0099	0,0001	0,2860	0,0863		34,0613	0,0003	0,0002	0,0035
61-18	0,5101	0,0110	0,0002	0,2509	0,0286		39,2609	0,0001	0,0004	0,0162
62-18	0,3364	0,0190	0,0001	0,2575	0,0231		46,9805	0,0001	0,0004	0,0108
63-18	0,9710	0,0074	0,0001	0,1364	0,0225		53,3169	0,0001	0,0007	0,0197
64-18	0,5848	0,0071	0,0001	0,2256	0,0288		45,1247	0,0001	0,0006	0,0172
65-18	0,8047	0,0098	0,0001	0,2592	0,0510		41,2829	0,0002	0,0005	0,0065
66-18	0,3504	0,0122	0,0002	0,3867	0,0633		39,8773	0,0001	0,0002	0,0146
67-18	0,1529	0,0124	0,0001	0,1593	0,0154		50,9055	0,0000	0,0001	0,0212
68-18	0,4313	0,0178	0,0001	0,4656	0,0303		33,5013	0,0001	0,0006	0,0090
69-18	0,0432	0,0035	0,0001	0,0338	0,0032		58,3088	0,0001	0,0000	0,0181
70-18	0,3197	0,0073	0,0001	0,2041	0,0202		46,9381	0,0001	0,0002	0,0271
71-18	0,3244	0,0177	0,0002	0,1980	0,0134		44,6890	0,0001	0,0002	0,0118
72-18	0,1352	0,0125	0,0001	0,1779	0,0200		53,0119	0,0003	0,0000	0,0116
73-18	0,2543	0,0062	0,0001	0,2550	0,0210		46,7692	0,0001	0,0001	0,0061
74-18	0,4111	0,0143	0,0001	0,3218	0,0279		40,2315	0,0001	0,0002	0,0190
1-16	3,3312	0,0058	0,0021	0,1992	0,0462	0,0042	37,6944		0,0030	0,1056
2-16	3,8682	0,0556	0,0011	0,1921	0,0751	0,0164	12,6639		0,0038	0,3399
3-16	7,9969	0,0180	0,0006	0,1604	0,0795	0,0088	15,7315		0,0099	0,0436
4-16	4,3031	0,0561	0,0008	0,1551	0,0309	0,0016	11,0301		0,0047	0,0260
5-16	26,9655	0,0235	0,0017	0,2359	0,1467	0,0021	13,5902		0,0320	0,0258
6-16	7,4350	0,0343	0,0013	0,2025	0,0755	0,0013	15,4282		0,0093	0,0187
7-16	13,0226	0,0179	0,0026	0,2084	0,0965	0,1724	9,7735		0,0130	0,0105
8-16	8,8743	0,0278	0,0023	0,2100	0,0713	0,0047	15,5566		0,0101	0,0264
9-16	3,4949	0,0180	0,0041	0,2502	0,0351	0,0040	13,7057		0,0055	0,0145
10-16	19,3739	0,0180	0,0038	0,1257	0,2820	0,0018	14,5230		0,0114	0,0152
11-16	6,9063	0,0357	0,0022	0,2232	0,1946	0,0022	341,7757		0,0085	0,0160
12-16	12,6234	0,0309	0,0008	0,2251	0,0989	0,0011	23,1313		0,0146	0,0181
13-16	1,6328	0,0058	0,0005	0,0483	0,0164	0,0005	3,6821		0,0045	0,0040
14-16	391,9171	0,0527	0,0038	0,2691	2,0401	0,0040	82,4208		0,3239	0,1009
15-16	932,0849	0,0936	0,0029	0,3386	4,9486	0,0055	419,8592		0,8203	0,3137

id	Al	As	Au	B	Ba	Bi	Ca	Cd	Ce	Co
16-16	17,7940	0,0733	0,0017	0,2508	0,2024	0,0059	17,9353		0,0248	0,1076
17a-16	4,7108	0,0099	0,0015	0,2201	0,0849	0,0048	32,7951		0,0076	0,0171
17b-16	7,5555	0,0177	0,0014	0,2277	0,0838	0,0018	20,2396		0,0080	0,0448
18-16	15,9602	0,0202	0,0043	0,2232	0,0495	0,0030	22,4498		0,0054	0,0657
19-16	7,8058	0,0141	0,0022	0,1684	0,0518	0,0031	14,0220		0,0057	0,0177
1-17	11,4927	0,0324	0,0086	0,2088	0,1085	0,0015	21,3151		0,0085	0,0274
2-17	22,6679	0,0258	0,0187	0,2918	0,1571	0,0029	49,5059		0,0162	0,0193
3-17	35,6129	0,0282	0,0214	0,4071	0,3004	0,0072	60,3351		0,0379	0,0231
4-17	33,1495	0,0217	0,0185	0,3396	0,2308	0,0024	47,0352		0,0316	0,0250
5-17	28,8977	0,0260	0,0107	0,1687	0,1769	0,0025	26,0538		0,0249	0,0267
6-17	132,4062	0,0396	0,0564	0,2843	0,8704	0,0138	242,7430		0,0996	0,0888
7-17	19,2874	0,0078	0,0116	0,2187	0,1823	0,0024	31,6214		0,0181	0,0551
8-17	47,2518	0,0238	0,0220	0,5254	0,5612	0,0042	395,2331		0,0319	0,0450
9-17	33,8468	0,0223	0,0071	0,2144	0,2053	0,0073	28,7513		0,0311	0,0227
10-17	25,7493	0,0795	0,0225	0,2048	0,1406	0,0021	27,8093		0,0204	0,0587
11-17	31,6407	0,0877	0,0245	0,2877	0,2630	0,0030	48,6496		0,0387	0,0371
12-17	26,9818	0,0394	0,0145	0,1843	0,1618	0,0048	38,0216		0,0226	0,0240
13-17	26,9104	0,0214	0,0339	0,1596	0,1636	0,0017	30,5784		0,0264	0,0282
14-17	54,2404	0,0600	0,0229	0,1896	0,4070	0,0059	25,9636		0,0695	0,0277
15-17	100,4564	0,0078	0,0205	0,2965	0,6944	0,0067	64,8537		0,1108	0,0273
16-17	66,8445	0,0255	0,0114	0,2586	0,4236	0,0053	53,4416		0,0670	0,0399
17-17	37,8980	0,0173	0,0330	0,2694	0,2802	0,0042	36,8944		0,0563	0,0183
18-17	12,9481	0,0235	0,0075	0,2841	0,1769	0,0019	104,6142		0,0282	0,0272
19-17	38,6906	0,0140	0,0263	0,2227	0,3293	0,0465	48,3070		0,0506	0,0207
20-17	80,4902	0,0399	0,0373	0,2644	0,5429	0,0043	57,7646		0,1012	0,0315
21-17	30,4780	0,0304	0,0430	0,2202	0,2127	0,0021	21,1925		0,0224	0,0136
22-17	37,4255	0,0186	0,0373	0,2815	0,2769	0,0037	130,7797		0,0383	0,0265
23-17	44,0330	0,0297	0,0142	0,2759	0,3040	0,0021	245,4444		0,0391	0,0346
24-17	15,2491	0,0078	0,0087	0,2480	0,1632	0,0012	96,1110		0,0175	0,0158
25-17	38,8141	0,0372	0,0368	0,3305	0,3996	0,0041	66,8253		0,0712	0,0335
26-17	70,1910	0,3409	0,0100	0,3756	1,0503	0,0024	315,9583		0,0624	0,1622
27-17	21,7901	0,0078	0,0055	0,1304	0,1056	0,0017	127,2386		0,0230	0,0152
28-17	21,4025	0,0078	0,0052	0,0947	0,1481	0,0021	77,0272		0,0212	0,0134
29-17	8,3844	0,0078	0,0041	0,0652	0,0501	0,0028	67,2916		0,0073	0,0113
30-17	5,5824	0,0078	0,0039	0,0800	0,0344	0,0012	77,4572		0,0050	0,0082
31-17	7,5080	0,0078	0,0056	0,0993	0,0473	0,0017	130,8990		0,0062	0,0119
32-17	11,4273	0,0426	0,0018	0,1161	0,0921	0,0010	108,5476		0,0097	0,0128
33-17	8,8831	0,0355	0,0025	0,1177	0,1161	0,0008	164,5655		0,0064	0,0151
34-17	5,3657	0,0390	0,0010	0,1081	0,0497	0,0009	96,1528		0,0029	0,0137
35-17	5,7960	0,0114	0,0016	0,0839	0,0343	0,0006	99,8130		0,0032	0,0136
36-17	11,5849	0,0164	0,0013	0,0879	0,0684	0,0007	95,2829		0,0099	0,0106
37-17	4,5935	0,0170	0,0015	0,6921	0,0331	0,0011	109,5834		0,0029	0,0084
38-17	20,4482	0,0078	0,0018	0,2445	0,0985	0,0005	96,5492		0,0155	0,0168
39-17	15,3047	0,0082	0,0013	0,2126	0,0712	0,0005	164,7821		0,0108	0,0543
40-17	9,5619	0,0100	0,0033	0,5663	0,0543	0,0005	114,2968		0,0108	0,0165
41-17	23,9696	0,0297	0,0028	0,1246	0,1027	0,0008	29,5355		0,0226	0,0164
42-17	9,9197	0,0267	0,0028	0,1389	0,0522	0,0004	16,6439		0,0063	0,0459
43-17	12,6299	0,0307	0,0025	0,1775	0,0542	0,0004	60,7098		0,0105	0,0267
44-17	19,2128	0,0477	0,0015	0,1249	0,0888	0,0009	66,4361		0,0203	0,0186
45-17	4,1141	0,0033	0,0016	0,2229	0,0305	0,0006	97,8414		0,0027	0,0126
46-17	2,4826	0,0072	0,0020	0,1863	0,0106	0,0006	109,3871		0,0019	0,0116
47-17	3,9331	0,0084	0,0014	0,1862	0,0335	0,0006	170,4741		0,0021	0,0206
48-17	14,5378	0,0033	0,0029	0,1473	0,1055	0,0022	110,7466		0,0237	0,0267
49-17	27,3784	0,0279	0,0047	0,0872	0,1732	0,0018	77,0067		0,0213	0,0312
50-17	34,3417	0,0078	0,0023	0,1171	0,1882	0,0045	137,2403		0,0266	0,0225
51-17	27,8592	0,0078	0,0014	0,1037	0,1557	0,0015	71,8296		0,0206	0,0151
52-17	20,2021	0,0078	0,0121	0,0944	0,1165	0,0054	64,4409		0,0146	0,0150
53-17	7,1975	0,0078	0,0052	0,0813	0,0479	0,0007	91,2282		0,0057	0,0099
54-17	5,4682	0,0078	0,0019	0,0982	0,0381	0,0005	112,4544		0,0033	0,0115
55-17	10,0585	0,0282	0,0027	0,1121	0,0617	0,0008	124,9024		0,0108	0,0094
56-17	9,8889	0,0142	0,0025	0,1172	0,0587	0,0012	46,0132		0,0059	0,0087
57-17	16,8249	0,0149	0,0016	0,1009	0,0756	0,0008	52,0888		0,0111	0,0094
58-17	16,8959	0,0078	0,0026	0,1020	0,0873	0,0007	67,7458		0,0129	0,0122
59-17	7,0240	0,0078	0,0029	0,1069	0,0269	0,0017	53,5463		0,0063	0,0183
60-17	4,3210	0,0078	0,0031	0,1149	0,0177	0,0013	63,7084		0,0024	0,0113
61-17	8,4079	0,0164	0,0030	0,0976	0,0389	0,0019	78,7490		0,0351	0,0243
62-17	6,1390	0,0078	0,0028	0,1312	0,0294	0,0034	91,9538		0,0053	0,0166
63-17	40,2373	0,0181	0,0017	0,1332	0,0939	0,0036	132,8388		0,0120	0,0515
64-17	7,4691	0,0158	0,0035	0,1042	0,0419	0,0009	131,0367		0,0038	0,0265
65-17	6,0407	0,0078	0,0075	0,0687	0,0291	0,0018	110,3432		0,0048	0,0081
66-17	2,6029	0,0078	0,0020	0,0717	0,0245	0,0008	106,9956		0,0027	0,0107
67-17	6,4296	0,0078	0,0023	0,0700	0,0466	0,0013	79,6715		0,0056	0,0116
68-17	7,6189	0,0078	0,0041	0,0743	0,0578	0,0008	110,2135		0,0158	0,0103
69-17	8,5676	0,0078	0,0029	0,1731	0,1632	0,0011	130,8506		0,0067	0,0115
70-17	2,6762	0,0078	0,0017	0,0760	0,0365	0,0013	106,2535		0,0021	0,0092
71-17	7,3393	0,0078	0,0029	0,0978	0,0667	0,0014	119,6837		0,0058	0,0085
1-18	4,6058	0,0124	0,0010	0,1255	0,0320	0,0015	15,7934		0,0033	0,0047
2-18	8,9256	0,0158	0,0012	0,2937	0,0709	0,0023	17,9592		0,0078	0,0095
3-18	9,3587	0,0286	0,0007	0,2227	0,0621	0,0016	20,5160		0,0228	0,0145
4-18	6,0719	0,0189	0,0021	0,1108	0,0401	0,0010	8,2517		0,0056	0,0084
5-18	5,9877	0,0180	0,0009	0,2627	0,0435	0,0006	18,7712		0,0052	0,0111

id	Al	As	Au	B	Ba	Bi	Ca	Cd	Ce	Co
6-18	38,5354	0,0272	0,0071	0,3051	0,2131	0,0733	30,7334		0,0316	0,0424
7-18	28,3254	0,0171	0,0265	0,3095	0,1343	0,0050	29,8598		0,0196	0,0181
8-18	10,3331	0,0354	0,0020	0,2240	0,0615	0,0009	17,9220		0,0094	0,0114
9-18	29,2625	0,0409	0,0015	0,2558	0,1635	0,0070	18,9126		0,0245	0,0185
10-18	18,1756	0,0104	0,0015	0,3864	0,1039	0,0034	15,0554		0,0198	0,0081
11-18	11,8183	0,0609	0,0010	0,2929	0,0920	0,0013	18,1065		0,0113	0,0141
12-18	21,0370	0,0130	0,0024	0,1978	0,1474	0,0018	22,2885		0,0176	0,0223
13-18	13,5385	0,0187	0,0024	0,2354	0,0856	0,0015	23,9252		0,0109	0,0127
14-18	16,1531	0,4109	0,0045	0,2054	0,0893	0,0025	20,2345		0,0152	0,0196
15-18	32,9054	0,0333	0,0052	0,2765	0,2037	0,0018	31,0660		0,0309	0,0452
16-18	24,0356	0,0147	0,0061	0,2367	0,1643	0,0024	18,8997		0,0232	0,0295
17-18	59,4121	0,0133	0,0057	0,2905	0,3408	0,0048	20,9096		0,0478	0,0265
18-18	21,7738	0,0090	0,0032	0,2435	0,1786	0,0015	20,7373		0,0179	0,0175
19-18	9,8040	0,0141	0,0047	0,2416	0,0736	0,0015	15,4006		0,0091	0,0065
20-18	20,2659	0,0363	0,0013	0,2452	0,1463	0,0038	44,1325		0,0266	0,0169
21-18	24,4124	0,0094	0,0010	0,2777	0,1639	0,0014	25,8768		0,0609	0,0351
22-18	16,4482	0,0239	0,0017	0,2545	0,1007	0,0025	20,5850		0,0160	0,0307
23-18	36,3637	0,0154	0,0014	0,2757	0,1708	0,0032	32,5039		0,0240	0,0368
24-18	19,8271	0,0306	0,0026	0,2841	0,1587	0,0031	37,7829		0,0166	0,0235
25-18	4,0330	0,0102	0,0005	0,2897	0,0377	0,0039	21,3858		0,0070	0,0083
26-18	167,0448	0,0377	0,0006	0,2206	0,9634	0,0016	65,9091		0,1651	0,1247
27-18	3,3083	0,0158	0,0008	0,0962	0,0230	0,0007	53,9939		0,0017	0,0114
28-18	13,1688	0,0775	0,0011	0,3882	0,0947	0,0007	108,4589		0,0055	0,0203
29-18	6,5158	0,1578	0,0003	0,0808	0,0443	0,0011	85,9355		0,0083	0,0125
30-18	4,9627	0,1119	0,0006	0,1620	0,0715	0,0014	51,4134		0,0041	0,0114
31-18	1,3994	0,0054	0,0015	0,1151	0,0221	0,0012	81,1845		0,0007	0,0130
32-18	14,4112	0,0114	0,0019	0,0877	0,0621	0,0005	42,5450		0,0079	0,0146
33-18	7,0284	0,0336	0,0016	0,1604	0,0392	0,0030	60,3568		0,0065	0,0143
34-18	9,1206	0,4161	0,0010	0,0748	0,0566	0,0006	65,9997		0,0060	0,0155
35-18	2,7375	0,0054	0,0009	0,1079	0,0209	0,0010	81,1267		0,0040	0,0119
36-18	15,6435	0,0111	0,0047	0,1082	0,0785	0,0016	25,8522		0,0088	0,0110
37-18	14,3988	0,0158	0,0020	0,1523	0,0794	0,0007	99,1655		0,0100	0,0247
38-18	11,5083	0,0282	0,0028	0,0701	0,1016	0,0012	30,2471		0,0123	0,0093
39-18	1,9037	0,0076	0,0005	0,1672	0,0237	0,0008	126,6634		0,0027	0,0094
40-18	2,6675	0,0033	0,0004	0,0765	0,0311	0,0009	69,5759		0,0030	0,0088
41-18	56,2166	0,0244	0,0038	0,1467	0,0801	0,0022	61,3616		0,0096	0,0453
42-18	2,0312	0,0158	0,0008	0,0930	0,0101	0,0007	37,5465		0,0014	0,0136

Table A20. Cont. of concentrations from all the samples (µg/g) from Cr to Ho. Empty cells means more than 50% of the concentrations were below LOD and discarded from the analysis.

id	Cr	Cs	Cu	Dy	Er	Fe	Ga	Gd	Hg	Ho
72-17	0,0167	0,0006	0,0594			81,8536		0,0001	0,0111	
73-17	0,0125	0,0010	0,0792			76,7821		0,0003	0,0078	
74-17	0,0160	0,0004	0,1189			124,0151		0,0002	0,0027	
75-17	0,0099	0,0010	0,1383			174,2787		0,0001	0,0192	
76-17	0,0039	0,0046	0,1495			159,0404		0,0000	0,0203	
77-17	0,0022	0,0006	0,1710			217,4892		0,0000	0,0159	
78-17	0,0016	0,0214	0,1767			256,8835		0,0000	0,0368	
79-17	0,0009	0,0010	0,1987			241,7192		0,0000	0,0363	
80-17	0,0017	0,0102	0,1778			238,6713		0,0000	0,0571	
81-17	0,0018	0,0049	0,2038			259,6783		0,0000	0,0339	
82-17	0,0060	0,0028	0,1662			231,4751		0,0000	0,0144	
83-17	0,0068	0,0017	0,1821			259,6103		0,0001	0,0176	
84-17	0,0047	0,0008	0,1438			187,1043		0,0000	0,0156	
85-17	0,0018	0,0073	0,1627			190,7580		0,0000	0,0146	
86-17	0,0361	0,0009	0,1028			103,5877		0,0000	0,0076	
87-17	0,0101	0,0011	0,0908			109,2073		0,0001	0,0067	
88-17	0,0035	0,0154	0,1589			227,3724		0,0000	0,0323	
89-17	0,0038	0,0015	0,1419			195,1162		0,0000	0,0232	
90-17	0,0114	0,0009	0,1476			214,3528		0,0001	0,0233	
91-17	0,0009	0,0028	0,1781			191,8662		0,0000	0,0427	
92-17	0,0018	0,0018	0,3885			228,7476		0,0000	0,0386	
93-17	0,0074	0,0024	0,2994			340,8398		0,0001	0,0470	
94-17	0,0039	0,0007	0,4409			551,3666		0,0001	0,0718	
95-17	0,0039	0,0017	0,2772			314,0535		0,0000	0,0600	
96-17	0,0100	0,0010	0,2880			267,2010		0,0000	0,0308	
97-17	0,0039	0,0031	0,3241			398,1228		0,0000	0,0770	
98-17	0,0039	0,0018	0,3013			272,5011		0,0001	0,0498	
99-17	0,0039	0,0010	0,2764			297,6062		0,0001	0,0841	
100-17	0,0039	0,0052	0,3818			355,5537		0,0000	0,1003	
101-17	0,0068	0,0055	0,3746			433,2327		0,0000	0,2912	
102-17	0,0084	0,0006	0,2460			221,0072		0,0000	0,0208	
103-17	0,0039	0,0010	0,3352			390,5408		0,0000	0,1352	
104-17	0,0009	0,0022	0,2971			405,3744		0,0000	0,1280	
43-18	0,0029	0,0006	0,2839			308,1586		0,0001	0,0728	
44-18	0,0052	0,0011	0,2345			273,2368		0,0014	0,0378	
45-18	0,0587	0,0015	0,5836			301,1474		0,0021	0,0588	
46-18	0,0094	0,0012	0,3592			307,2351		0,0001	0,0548	
48-18	0,0827	0,0011	0,2314			156,4825		0,0002	0,0380	
49-18	0,0158	0,0009	0,2013			101,0980		0,0007	0,0330	

id	Cr	Cs	Cu	Dy	Er	Fe	Ga	Gd	Hg	Ho
50-18	0,0090	0,0138	0,2821			276,3354		0,0002	0,0543	
51-18	0,0073	0,0022	0,2165			272,1617		0,0002	0,0390	
52-18	0,0019	0,0013	0,3030			367,4549		0,0000	0,0644	
53-18	0,0145	0,0003	0,1335			153,2625		0,0000	0,0286	
54-18	0,0060	0,0012	0,2505			273,1960		0,0001	0,0489	
55-18	0,0016	0,0037	0,2533			313,6637		0,0000	0,0844	
56-18	0,0048	0,0031	0,2355			250,3105		0,0000	0,0460	
57-18	0,0050	0,0057	0,2974			313,8582		0,0000	0,0467	
58-18	0,0062	0,0009	0,2280			251,3850		0,0001	0,0371	
59-18	0,0023	0,0023	0,2263			335,1666		0,0001	0,0959	
61-18	0,0069	0,0018	0,1677			257,3554		0,0001	0,0206	
62-18	0,0038	0,0006	0,1199			220,2062		0,0000	0,0130	
63-18	0,0297	0,0577	0,1203			254,6196		0,0001	0,0291	
64-18	0,0037	0,0105	0,1662			238,7545		0,0001	0,0206	
65-18	0,0042	0,0010	0,1663			267,7052		0,0001	0,0324	
66-18	0,0061	0,0003	0,1074			147,7362		0,0001	0,0309	
67-18	0,0022	0,0032	0,1778			280,6472		0,0000	0,0345	
68-18	0,0032	0,0059	0,1218			184,6744		0,0001	0,0261	
69-18	0,0008	0,0002	0,1983			309,5745		0,0000	0,0425	
70-18	0,0031	0,0008	0,1507			213,9597		0,0001	0,0264	
71-18	0,0025	0,0013	0,1587			248,3944		0,0000	0,0502	
72-18	0,0019	0,0010	0,1537			230,8328		0,0000	0,0395	
73-18	0,0025	0,0102	0,1545			210,2327		0,0000	0,0317	
74-18	0,0073	0,0031	0,0909			172,4244		0,0001	0,0190	
1-16	0,2132	0,0007	2,3648	0,0002	0,0002	15,0485	0,0011		1,1061	0,0001
2-16	0,0472	0,0006	2,6672	0,0006	0,0003	7,7673	0,0034		0,6778	0,0002
3-16	0,0748	0,0006	2,0602	0,0006	0,0003	13,4401	0,0034		0,8853	0,0003
4-16	0,0251	0,0004	3,0433	0,0006	0,0003	7,4198	0,0034		0,7011	0,0002
5-16	0,1133	0,0026	2,3653	0,0046	0,0008	26,3462	0,0073		0,7919	0,0004
6-16	0,0439	0,0005	2,9224	0,0006	0,0003	26,9234	0,0024		0,5616	0,0002
7-16	0,0659	0,0011	2,6248	0,0002	0,0005	13,2162	0,0037		0,8803	0,0002
8-16	0,0435	0,0010	2,5950	0,0002	0,0002	9,1997	0,0022		1,4797	0,0002
9-16	0,0564	0,0003	2,1976	0,0002	0,0002	6,7187	0,0011		1,3402	0,0001
10-16	0,0491	0,0011	2,5335	0,0006	0,0004	15,7378	0,0034		0,8600	0,0003
11-16	0,0367	0,0013	3,8100	0,0006	0,0005	12,1736	0,0034		0,9144	0,0002
12-16	0,0684	0,0011	2,3127	0,0007	0,0006	16,3678	0,0028		0,8100	0,0002
13-16	0,0217	0,0001	0,9119	0,0002	0,0002	2,8616	0,0011		0,1763	0,0001
14-16	0,6988	0,0232	2,7457	0,0260	0,0147	251,8253	0,0995		0,7686	0,0051
15-16	1,6508	0,0483	3,0201	0,0574	0,0338	730,0031	0,2417		1,9530	0,0116
16-16	0,1978	0,0010	2,9002	0,0013	0,0005	19,8330	0,0055		1,1949	0,0002
17a-16	0,0383	0,0005	2,6797	0,0002	0,0002	10,4466	0,0011		0,9183	0,0001
17b-16	0,0360	0,0008	2,6550	0,0002	0,0002	11,2445	0,0011		1,0179	0,0002
18-16	0,0565	0,0004	2,9661	0,0002	0,0002	14,8809	0,0023		1,1199	0,0002
19-16	0,0920	0,0004	2,3868	0,0002	0,0003	11,0143	0,0014		1,1277	0,0002
1-17	0,0595	0,0018	3,4369	0,0007	0,0004	16,4964	0,0035		1,0145	0,0002
2-17	0,1065	0,0015	3,6929	0,0011	0,0007	24,5314	0,0061		1,9368	0,0002
3-17	0,3272	0,0026	3,1427	0,0022	0,0015	36,4371	0,0085		1,2513	0,0005
4-17	0,1944	0,0036	3,4262	0,0022	0,0011	38,1398	0,0080		0,8516	0,0005
5-17	0,0861	0,0017	3,6305	0,0017	0,0011	35,0396	0,0066		1,2656	0,0003
6-17	0,3106	0,0093	2,8974	0,0062	0,0034	97,4788	0,0321		1,2381	0,0013
7-17	0,0540	0,0011	3,3887	0,0011	0,0007	21,9898	0,0052		1,9704	0,0003
8-17	0,1549	0,0025	2,9123	0,0028	0,0012	46,4394	0,0107		0,7037	0,0005
9-17	0,1360	0,0026	3,2856	0,0020	0,0010	36,9519	0,0084		0,7791	0,0004
10-17	0,1736	0,0014	4,3358	0,0014	0,0008	26,2683	0,0060		0,7104	0,0008
11-17	0,1191	0,0020	4,1772	0,0026	0,0018	34,8724	0,0077		0,8929	0,0005
12-17	0,1122	0,0019	9,6069	0,0014	0,0009	40,7354	0,0064		0,8676	0,0003
13-17	0,0920	0,0020	2,9623	0,0017	0,0010	30,9905	0,0078		1,1317	0,0002
14-17	0,2367	0,0044	3,3365	0,0043	0,0026	47,4292	0,0144		1,3499	0,0009
15-17	0,2307	0,0082	3,5616	0,0058	0,0037	71,0561	0,0261		1,1207	0,0012
16-17	0,1790	0,0058	3,1560	0,0043	0,0025	53,3553	0,0170		1,0375	0,0008
17-17	0,2380	0,0024	3,0232	0,0026	0,0014	38,2923	0,0092		1,5481	0,0004
18-17	0,0746	0,0017	4,0996	0,0006	0,0004	33,1735	0,0040		1,3452	0,0002
19-17	0,1917	0,0029	3,3646	0,0023	0,0014	35,3608	0,0092		1,5774	0,0005
20-17	0,1642	0,0079	3,2738	0,0057	0,0029	71,3142	0,0199		0,7633	0,0010
21-17	0,0920	0,0017	3,5634	0,0018	0,0011	33,4715	0,0084		1,4653	0,0003
22-17	0,1135	0,0029	3,2221	0,0028	0,0016	37,6458	0,0083		0,5787	0,0005
23-17	0,1082	0,0032	3,2609	0,0022	0,0013	49,5438	0,0095		0,9618	0,0004
24-17	0,0498	0,0015	2,9893	0,0012	0,0007	18,5545	0,0035		1,2375	0,0002
25-17	0,1527	0,0025	4,1543	0,0047	0,0027	63,9170	0,0108		1,5174	0,0008
26-17	0,2982	0,0058	4,7660	0,0045	0,0028	83,7863	0,0151		1,6180	0,0009
27-17	0,0799	0,0014	2,3670	0,0013	0,0007	23,7874	0,0059		0,7655	0,0003
28-17	0,0961	0,0014	2,3916	0,0014	0,0006	21,1211	0,0044		0,7170	0,0002
29-17	0,0604	0,0004	1,8632	0,0006	0,0004	14,7575	0,0022		1,4537	0,0001
30-17	0,0565	0,0005	2,1927	0,0003	0,0002	12,8899	0,0022		1,2665	0,0001
31-17	0,0400	0,0007	2,4973	0,0003	0,0003	17,8423	0,0022		1,2159	0,0001
32-17	0,0533	0,0004	1,9175	0,0009	0,0007	17,7600	0,0023		0,3178	0,0002
33-17	0,0452	0,0005	1,5897	0,0004	0,0004	17,3478	0,0031		0,3464	0,0000
34-17	0,0525	0,0002	1,6741	0,0003	0,0002	12,9745	0,0019		0,3236	0,0000
35-17	0,0516	0,0003	1,8383	0,0003	0,0001	13,8281	0,0009		0,6721	0,0000
36-17	0,0506	0,0007	1,9702	0,0007	0,0003	18,2048	0,0022		0,7690	0,0001
37-17	0,0776	0,0002	1,6149	0,0001	0,0002	12,9566	0,0009		0,7148	0,0001
38-17	0,0746	0,0016	1,4441	0,0012	0,0009	24,4243	0,0057		0,6716	0,0002
39-17	0,0540	0,0011	2,3555	0,0010	0,0007	21,5648	0,0042		0,7068	0,0002
40-17	0,0530	0,0007	1,7241	0,0010	0,0003	23,2547	0,0028		0,8259	0,0002
41-17	0,0788	0,0010	1,9659	0,0022	0,0013	27,3799	0,0060		0,4995	0,0004
42-17	0,0629	0,0008	1,5864	0,0008	0,0004	16,3646	0,0037		0,5019	0,0002

id	Cr	Cs	Cu	Dy	Er	Fe	Ga	Gd	Hg	Ho
43-17	0,0690	0,0007	1,9132	0,0006	0,0003	18,0785	0,0031		0,4994	0,0001
44-17	0,0649	0,0010	1,9981	0,0019	0,0009	28,2777	0,0047		0,4533	0,0003
45-17	0,0600	0,0003	1,9060	0,0007	0,0002	14,0454	0,0009		0,5227	0,0000
46-17	0,0435	0,0003	1,5891	0,0005	0,0001	13,5443	0,0009		0,5313	0,0000
47-17	0,0268	0,0003	2,2155	0,0002	0,0001	18,1676	0,0009		0,5643	0,0000
48-17	0,0754	0,0018	2,1428	0,0019	0,0007	22,5651	0,0038		0,6459	0,0003
49-17	0,0779	0,0017	1,6623	0,0015	0,0010	29,2220	0,0063		1,0065	0,0003
50-17	0,0973	0,0035	2,3203	0,0029	0,0015	30,9373	0,0079		0,4344	0,0005
51-17	0,0688	0,0029	1,7476	0,0019	0,0010	23,1331	0,0072		0,6545	0,0004
52-17	0,0727	0,0018	1,6450	0,0010	0,0006	21,2450	0,0050		0,9688	0,0002
53-17	0,0374	0,0007	1,9285	0,0004	0,0002	14,9135	0,0022		0,6887	0,0001
54-17	0,0410	0,0005	2,0564	0,0003	0,0002	14,0968	0,0022		0,7988	0,0001
55-17	0,1183	0,0007	3,0932	0,0005	0,0003	16,2567	0,0022		0,9252	0,0001
56-17	0,1275	0,0008	1,9845	0,0005	0,0003	14,2125	0,0022		0,7505	0,0001
57-17	0,1424	0,0011	2,2459	0,0013	0,0007	19,5879	0,0036		0,6990	0,0002
58-17	0,1674	0,0014	2,8281	0,0010	0,0005	21,6072	0,0047		0,9552	0,0002
59-17	0,0656	0,0003	1,7121	0,0006	0,0003	13,7133	0,0022		0,8313	0,0001
60-17	0,0468	0,0002	1,7329	0,0003	0,0001	10,0268	0,0022		0,8750	0,0001
61-17	0,0683	0,0003	1,7835	0,0005	0,0002	15,8984	0,0022		1,6417	0,0001
62-17	0,0515	0,0005	2,0311	0,0006	0,0003	14,5558	0,0022		1,3825	0,0001
63-17	0,1433	0,0015	1,6888	0,0018	0,0011	43,2426	0,0108		0,9207	0,0004
64-17	0,0549	0,0005	1,7811	0,0008	0,0003	18,5712	0,0022		1,0401	0,0001
65-17	0,0564	0,0003	2,0394	0,0003	0,0002	12,3596	0,0022		0,7595	0,0001
66-17	0,0381	0,0002	1,9693	0,0003	0,0001	10,1844	0,0022		0,8846	0,0001
67-17	0,1627	0,0005	2,3762	0,0003	0,0003	14,8819	0,0022		1,0141	0,0001
68-17	0,0419	0,0004	1,7814	0,0009	0,0003	17,1745	0,0022		1,2333	0,0001
69-17	0,0406	0,0014	1,9555	0,0006	0,0002	15,4866	0,0022		0,7243	0,0001
70-17	0,0403	0,0005	1,7608	0,0003	0,0001	10,1449	0,0022		0,7254	0,0001
71-17	0,0503	0,0034	1,7250	0,0003	0,0002	15,3159	0,0022		0,9610	0,0001
1-18	0,0275	0,0003	1,2592	0,0002	0,0002	5,4484	0,0013		0,4206	0,0001
2-18	0,0939	0,0011	2,8509	0,0007	0,0004	11,9910	0,0039		1,6110	0,0002
3-18	0,0606	0,0007	3,2415	0,0005	0,0004	11,7610	0,0027		0,8696	0,0001
4-18	0,0476	0,0004	1,3471	0,0004	0,0003	7,6476	0,0015		0,2695	0,0001
5-18	0,0427	0,0004	2,1620	0,0005	0,0002	9,8855	0,0023		0,7686	0,0002
6-18	0,1218	0,0024	3,0450	0,0024	0,0014	53,1904	0,0093		0,9364	0,0004
7-18	0,0831	0,0015	2,7389	0,0013	0,0008	32,9919	0,0070		0,9106	0,0003
8-18	0,0268	0,0009	3,0126	0,0008	0,0004	16,5160	0,0036		0,6890	0,0002
9-18	0,1257	0,0020	2,4797	0,0014	0,0011	27,3209	0,0085		0,7242	0,0003
10-18	0,0651	0,0016	2,7599	0,0011	0,0007	16,5614	0,0056		0,7803	0,0003
11-18	0,0591	0,0012	2,7813	0,0007	0,0004	12,4637	0,0034		0,7877	0,0001
12-18	0,0602	0,0016	3,3648	0,0012	0,0009	22,8595	0,0068		0,6418	0,0003
13-18	0,0504	0,0010	2,9674	0,0007	0,0003	15,4906	0,0036		0,9924	0,0002
14-18	0,0614	0,0018	3,2403	0,0009	0,0006	18,5462	0,0049		1,4865	0,0002
15-18	0,0864	0,0039	3,4723	0,0023	0,0017	38,7971	0,0105		0,8391	0,0005
16-18	0,1066	0,0013	2,7305	0,0017	0,0012	22,2313	0,0058		0,6158	0,0003
17-18	0,1342	0,0054	2,7046	0,0034	0,0018	41,9069	0,0185		0,7791	0,0007
18-18	0,0543	0,0020	3,0310	0,0009	0,0006	18,4509	0,0062		1,4106	0,0003
19-18	0,0407	0,0005	2,8972	0,0010	0,0006	11,1548	0,0033		0,9976	0,0002
20-18	0,1224	0,0019	2,6074	0,0013	0,0009	21,0530	0,0058		1,9344	0,0003
21-18	0,1339	0,0029	3,0421	0,0019	0,0009	26,3966	0,0079		0,8551	0,0003
22-18	0,2878	0,0014	3,0921	0,0012	0,0007	22,9410	0,0045		2,0545	0,0002
23-18	0,1403	0,0026	3,6813	0,0022	0,0011	42,6982	0,0109		0,8534	0,0004
24-18	0,1191	0,0015	3,3616	0,0016	0,0008	22,5957	0,0055		1,2732	0,0003
25-18	0,0252	0,0004	2,5142	0,0004	0,0002	8,1179	0,0013		0,9834	0,0000
26-18	0,3114	0,0139	3,1389	0,0100	0,0053	114,4685	0,0395		1,3756	0,0020
27-18	0,0419	0,0011	0,9222	0,0005	0,0003	8,5583	0,0039		0,5847	0,0001
28-18	0,1539	0,0031	1,4916	0,0027	0,0005	15,8606	0,0039		0,7234	0,0003
29-18	0,0349	0,0005	1,5221	0,0008	0,0002	27,6498	0,0039		0,3644	0,0001
30-18	0,3067	0,0005	1,1609	0,0005	0,0007	20,5312	0,0039		0,3212	0,0002
31-18	0,0348	0,0035	1,4473	0,0002	0,0001	6,8158	0,0013		0,4309	0,0000
32-18	0,0639	0,0009	3,2594	0,0011	0,0008	19,1675	0,0035		0,5423	0,0002
33-18	0,0563	0,0005	1,8574	0,0015	0,0005	11,8079	0,0019		0,5836	0,0004
34-18	0,0357	0,0014	1,6538	0,0003	0,0003	12,4569	0,0035		0,6705	0,0002
35-18	0,0246	0,0065	1,5485	0,0004	0,0001	10,3439	0,0013		0,5315	0,0001
36-18	0,0817	0,0013	1,8384	0,0008	0,0005	13,9275	0,0035		0,7027	0,0001
37-18	0,0644	0,0012	1,6535	0,0007	0,0008	17,4945	0,0039		0,5283	0,0002
38-18	0,0386	0,0008	2,0397	0,0005	0,0004	12,5445	0,0030		1,0138	0,0001
39-18	0,0224	0,0086	1,3880	0,0002	0,0001	12,7533	0,0013		0,9072	0,0001
40-18	0,0274	0,0008	1,3906	0,0002	0,0001	11,7550	0,0013		0,4462	0,0001
41-18	0,2549	0,0022	1,5240	0,0041	0,0021	85,2340	0,0166		0,7909	0,0009
42-18	0,0589	0,0011	1,5664	0,0005	0,0002	8,8819	0,0039		0,4569	0,0001

Table A21. Continuation of concentrations from all the samples (µg/g) from K to Ni. Empty cells means more than 50% of the concentrations were below LOD and discarded from the analysis.

id	K	La	Li	Lu	Mg	Mn	Mo	Na	Nd	Ni
72-17	314,0726	0,0004	0,0090		20,2803	0,0158	0,0075	4908,7788	0,0002	0,0222
73-17	424,1999	0,0001	0,0439		28,1729	0,0206	0,0162	4188,3688	0,0004	0,0283
74-17	591,3857	0,0008	0,0310		35,8782	0,0208	0,0196	3908,9521	0,0009	0,0162
75-17	825,5374	0,0001	0,0148		51,1235	0,0539	0,0093	3441,7459	0,0002	0,0088
76-17	1119,2587	0,0001	0,0149		69,1690	0,0723	0,0153	2866,7980	0,0001	0,0058
77-17	968,9227	0,0000	0,0046		56,1670	0,0170	0,0078	2546,0509	0,0000	0,0034
78-17	1097,9936	0,0000	0,0032		63,9176	0,0210	0,0155	2500,3158	0,0000	0,0028
79-17	1055,8783	0,0000	0,0011		58,7418	0,0263	0,0218	2606,7433	0,0000	0,0033
80-17	1075,4801	0,0000	0,0009		61,2602	0,0352	0,0174	2559,4044	0,0000	0,0025
81-17	1237,7853	0,0000	0,0063		68,0871	0,0452	0,0138	2430,0878	0,0000	0,0023
82-17	1113,7017	0,0000	0,0067		64,4878	0,0243	0,0234	2599,0991	0,0001	0,0040
83-17	1220,2474	0,0001	0,0688		71,7987	0,0572	0,0255	2446,0631	0,0005	0,0105
84-17	895,0237	0,0000	0,0071		51,7498	0,0244	0,0132	2955,8325	0,0001	0,0062
85-17	979,0637	0,0000	0,0078		58,7494	0,0228	0,0179	2942,3380	0,0001	0,0049
86-17	468,4407	0,0004	0,0723		28,3752	0,0446	0,0166	4843,0829	0,0002	0,0184
87-17	507,1625	0,0001	0,0303		30,4898	0,0205	0,0138	4080,9242	0,0004	0,0140
88-17	1062,4205	0,0000	0,0124		61,6666	0,0408	0,0116	2733,8912	0,0001	0,0043
89-17	843,8895	0,0000	0,0083		47,7909	0,0282	0,0211	3124,0777	0,0001	0,0079
90-17	936,9239	0,0000	0,0097		52,8689	0,0164	0,0187	2937,2939	0,0002	0,0050
91-17	954,6183	0,0000	0,0020		60,0291	0,0219	0,0115	2575,5659	0,0000	0,0022
92-17	1091,3423	0,0000	0,0015		60,7555	0,0295	0,0182	2570,1169	0,0000	0,0032
93-17	1224,8318	0,0001	0,0041		56,5234	0,0197	0,0204	2633,9232	0,0001	0,0032
94-17	1923,0611	0,0001	0,0036		79,7839	0,0226	0,0254	1875,0822	0,0001	0,0032
95-17	1172,3266	0,0001	0,0058		48,5197	0,0252	0,0193	3130,0525	0,0001	0,0080
96-17	1045,4866	0,0001	0,0075		49,2344	0,0195	0,0239	3057,5659	0,0001	0,0067
97-17	1523,8104	0,0001	0,0065		63,5910	0,0225	0,0292	2409,1892	0,0002	0,0032
98-17	1191,7984	0,0001	0,0060		56,8863	0,0146	0,0270	2581,0431	0,0001	0,0032
99-17	1140,4677	0,0001	0,0119		48,4471	0,0177	0,0238	3056,7109	0,0002	0,0065
100-17	1417,5758	0,0001	0,0085		64,6316	0,0324	0,0273	2298,8632	0,0001	0,0032
101-17	1595,0876	0,0001	0,0091		68,1124	0,0592	0,0201	2167,7947	0,0002	0,0053
102-17	1110,8707	0,0002	0,0053		55,7756	0,0132	0,0248	3011,7130	0,0001	0,0051
103-17	1424,2089	0,0001	0,0050		66,6688	0,0158	0,0390	2203,4551	0,0001	0,0055
104-17	1383,6550	0,0001	0,0006		63,8413	0,0173	0,0196	2369,8392	0,0001	0,0034
43-18	1102,5394	0,0001	0,0014		49,6575	0,0520	0,0321	2699,5342	0,0000	0,0064
44-18	1076,9047	0,0011	0,0017		46,3515	0,0488	0,0243	2851,9863	0,0010	0,0080
45-18	1299,6998	0,0056	0,0174		57,8855	0,2022	0,0217	4718,7045	0,0061	0,0288
46-18	1211,5275	0,0004	0,0013		54,0145	0,0623	0,0393	2920,6672	0,0003	0,0072
48-18	866,8043	0,0010	0,0028		49,0364	0,0475	0,0412	2981,7881	0,0010	0,0580
49-18	933,8536	0,0023	0,0062		39,2563	0,0725	0,0171	3335,0655	0,0023	0,0138
50-18	837,0691	0,0007	0,0021		43,2906	0,1157	0,0277	3274,1472	0,0012	0,0093
51-18	816,8489	0,0004	0,0017		38,6730	0,0315	0,0241	3402,2433	0,0002	0,0085
52-18	1290,7760	0,0001	0,0010		55,5139	0,0324	0,0348	2478,4070	0,0001	0,0036
53-18	550,1658	0,0001	0,0032		23,6183	0,0109	0,0100	3982,2534	0,0003	0,0211
54-18	963,5500	0,0003	0,0019		43,1575	0,0172	0,0255	2965,1126	0,0002	0,0057
55-18	1133,4403	0,0001	0,0003		46,2329	0,0152	0,0272	2721,5181	0,0001	0,0046
56-18	713,0465	0,0002	0,0006		34,0249	0,0175	0,0139	3445,1847	0,0004	0,0089
57-18	1263,8649	0,0004	0,0006		51,1316	0,0426	0,0378	2377,4952	0,0001	0,0035
58-18	947,4136	0,0002	0,0006		41,0426	0,0198	0,0228	3147,6035	0,0001	0,0051
59-18	1091,5748	0,0002	0,0003		45,6958	0,0148	0,0234	2784,4513	0,0001	0,0045
61-18	1110,5222	0,0003	0,0003		55,9499	0,0282	0,0166	2709,1338	0,0002	0,0053
62-18	1020,2662	0,0002	0,0003		50,1392	0,0189	0,0218	2786,1008	0,0002	0,0045
63-18	1269,1806	0,0003	0,0010		66,1805	0,0479	0,0142	2398,1492	0,0003	0,0022
64-18	1091,6076	0,0003	0,0003		59,5489	0,0308	0,0161	2652,5201	0,0003	0,0034
65-18	1128,9122	0,0002	0,0003		51,8229	0,0274	0,0153	2826,5264	0,0002	0,0042
66-18	734,6702	0,0001	0,0018		32,9693	0,0101	0,0087	3285,0273	0,0001	0,0070
67-18	1238,4228	0,0000	0,0002		58,1915	0,0143	0,0117	2560,6367	0,0000	0,0036
68-18	797,9519	0,0004	0,0022		40,7533	0,0216	0,0113	3270,7034	0,0003	0,0072
69-18	1310,1548	0,0000	0,0005		65,8415	0,0247	0,0175	2311,6600	0,0000	0,0006
70-18	1096,8669	0,0001	0,0010		59,8327	0,0224	0,0216	2667,6890	0,0001	0,0034
71-18	1026,1236	0,0001	0,0010		50,7588	0,0227	0,0231	2589,0410	0,0002	0,0026
72-18	1018,5837	0,0000	0,0007		46,5021	0,0128	0,0167	2711,6031	0,0001	0,0028
73-18	1154,9329	0,0000	0,0014		64,7865	0,0409	0,0188	2812,9707	0,0001	0,0043
74-18	921,6811	0,0002	0,0024		46,6398	0,0309	0,0150	3006,1668	0,0001	0,0052
1-16	1,8751	0,0015		0,0000	11,1887	0,2418	0,0585	8,1428	0,0012	0,0483
2-16	3,5940	0,0087		0,0001	5,3983	0,1901	0,0873	7,6672	0,0028	0,0267
3-16	3,5940	0,0065		0,0001	8,4947	0,1129	0,0747	7,6672	0,0040	0,0387
4-16	3,5940	0,0026		0,0001	3,7881	0,1296	0,0787	7,6672	0,0020	0,0267
5-16	6,1744	0,0082		0,0002	12,3757	0,2747	0,0727	10,1954	0,0091	0,0476
6-16	2,3841	0,0037		0,0000	5,6609	0,2944	0,0944	6,7913	0,0040	0,0148
7-16	4,8598	0,0052		0,0000	10,0398	0,2479	0,1461	7,2198	0,0047	0,0259
8-16	3,8997	0,0042		0,0001	9,0408	0,1175	0,1230	7,7897	0,0031	0,0199
9-16	1,1569	0,0025		0,0000	7,2693	0,2546	0,0637	5,4543	0,0019	0,0198
10-16	9,6912	0,0047		0,0001	7,7513	0,1600	0,0702	11,1243	0,0045	0,0267
11-16	20,7876	0,0053		0,0001	107,9987	0,5630	0,1636	16,2850	0,0056	0,0335
12-16	11,5233	0,0078		0,0001	13,7176	0,2552	0,0767	14,8181	0,0056	0,0330
13-16	1,1569	0,0022		0,0000	1,8635	0,0447	0,0271	2,4681	0,0033	0,0086
14-16	108,6215	0,1340		0,0019	99,2898	4,1948	0,0883	60,8678	0,1372	0,2628
15-16	237,5825	0,3721		0,0042	354,624	13,1758	0,0805	102,0992	0,3681	0,7201
16-16	5,3342	0,0125		0,0001	9,7053	0,4031	0,0793	10,9671	0,0107	0,0315
17a-16	1,6203	0,0036		0,0000	12,4528	0,5518	0,0555	7,7991	0,0038	0,0151
17b-16	2,7148	0,0045		0,0000	9,3239	0,4629	0,0660	8,5136	0,0042	0,0195

id	K	La	Li	Lu	Mg	Mn	Mo	Na	Nd	Ni
18-16	2,5106	0,0029		0,0000	11,1676	0,2214	0,1242	9,6008	0,0020	0,0587
19-16	1,6109	0,0028		0,0000	6,4831	0,1403	0,1012	5,4865	0,0025	0,0160
1-17	4,3967	0,0034		0,0001	8,7500	0,3364	0,0887	7,6786	0,0041	0,0375
2-17	6,5531	0,0071		0,0001	21,5629	0,5621	0,1212	10,7037	0,0069	0,0426
3-17	13,5395	0,0173		0,0002	23,7087	0,5774	0,1037	12,8946	0,0169	0,0578
4-17	9,4257	0,0163		0,0002	22,3808	0,5653	0,0939	8,7906	0,0163	0,0874
5-17	10,6839	0,0113		0,0001	12,2059	0,3065	0,0830	13,1227	0,0120	0,0370
6-17	37,6276	0,0424		0,0004	65,5333	3,3906	0,0901	42,0966	0,0450	0,1242
7-17	5,6819	0,0076		0,0001	10,0807	0,4063	0,0816	9,8185	0,0079	0,0217
8-17	16,7358	0,0138		0,0002	24,5237	0,6447	0,1113	14,9210	0,0144	0,0645
9-17	12,2426	0,0148		0,0002	16,3052	0,4006	0,0699	11,8958	0,0157	0,0374
10-17	8,3711	0,0088		0,0001	14,7003	0,3625	0,1343	12,4446	0,0096	0,0658
11-17	7,7708	0,0201		0,0002	18,5356	0,9498	0,1270	12,5535	0,0200	0,0574
12-17	23,4089	0,0100		0,0001	15,3521	0,3707	0,1413	20,7238	0,0097	0,4153
13-17	14,5396	0,0117		0,0001	16,4375	0,4831	0,0904	12,2149	0,0113	0,0470
14-17	20,4769	0,0278		0,0004	19,6418	0,6980	0,0881	15,6586	0,0297	0,0672
15-17	35,6288	0,0466		0,0004	40,6486	0,9491	0,1039	24,4566	0,0444	0,0796
16-17	30,7328	0,0310		0,0003	27,6206	0,6853	0,0761	18,1935	0,0315	0,0767
17-17	10,0832	0,0235		0,0001	15,8620	0,6204	0,0994	13,0156	0,0190	0,0767
18-17	14,8904	0,0122		0,0001	25,5470	0,7447	0,2769	18,4943	0,0103	0,0859
19-17	23,0660	0,0211		0,0002	22,1026	0,6717	0,0988	18,9615	0,0187	0,0732
20-17	37,6901	0,0440		0,0004	37,5859	0,8272	0,1232	28,0882	0,0458	0,0923
21-17	8,6322	0,0106		0,0002	12,6405	0,3615	0,1219	10,2777	0,0108	0,0328
22-17	16,9991	0,0156		0,0002	47,8674	0,7400	0,0874	22,3589	0,0186	0,0484
23-17	25,5557	0,0182		0,0002	94,5113	1,3212	0,0804	31,8699	0,0173	0,0657
24-17	12,0652	0,0080		0,0001	40,9427	0,5521	0,0799	19,3164	0,0084	0,0269
25-17	10,3937	0,0389		0,0003	24,3268	0,8408	0,1009	8,7747	0,0326	0,0859
26-17	27,2526	0,0333		0,0004	75,5623	11,2169	0,1561	19,1835	0,0322	0,3208
27-17	51,0244	0,0084		0,0001	121,395	0,2563	0,1479	64,5064	0,0103	0,0280
28-17	25,3195	0,0093		0,0001	75,1354	0,2365	0,1113	36,7701	0,0092	0,0270
29-17	6,1007	0,0038		0,0001	51,9759	0,1420	0,0696	10,2316	0,0028	0,0153
30-17	17,1050	0,0016		0,0001	71,8884	0,1181	0,1032	23,3628	0,0022	0,0104
31-17	62,0506	0,0036		0,0001	121,936	0,1706	0,1232	86,9384	0,0036	0,0202
32-17	5,6192	0,0044		0,0001	88,9705	0,2693	0,1316	7,5766	0,0042	0,0152
33-17	26,5550	0,0026		0,0001	151,102	0,2320	0,1481	40,2304	0,0027	0,0104
34-17	2,6069	0,0010		0,0000	80,9462	0,1358	0,1327	2,5627	0,0012	0,0067
35-17	3,8352	0,0016		0,0000	92,7351	0,1150	0,0487	4,3766	0,0017	0,0127
36-17	8,9778	0,0042		0,0001	95,6943	0,1885	0,0750	10,2125	0,0046	0,0131
37-17	3,1545	0,0025		0,0001	79,3237	0,1094	0,0500	3,3621	0,0013	0,0172
38-17	9,2310	0,0066		0,0001	82,1530	0,2766	0,0395	10,5544	0,0069	0,0194
39-17	27,9836	0,0049		0,0001	134,835	0,2192	0,0293	34,9007	0,0054	0,0147
40-17	6,0754	0,0051		0,0001	79,9870	0,2432	0,0616	4,6376	0,0061	0,0200
41-17	4,9228	0,0096		0,0001	23,7398	0,2734	0,0917	5,9007	0,0102	0,0202
42-17	3,0939	0,0031		0,0001	10,1227	0,1016	0,1128	2,4208	0,0031	0,0207
43-17	4,1101	0,0053		0,0001	48,3364	0,1677	0,0636	4,9434	0,0040	0,0118
44-17	3,9452	0,0097		0,0001	57,2288	0,2902	0,1136	4,1969	0,0096	0,0202
45-17	6,3413	0,0017		0,0000	71,5227	0,1266	0,0466	3,1805	0,0012	0,0169
46-17	3,6368	0,0009		0,0000	91,5105	0,1024	0,0610	4,6564	0,0010	0,0161
47-17	8,1815	0,0010		0,0000	155,349	0,1833	0,0803	11,8331	0,0016	0,0131
48-17	7,6361	0,0149		0,0001	92,3189	0,2226	0,1296	7,2794	0,0128	0,0359
49-17	9,0788	0,0097		0,0002	66,4264	0,3350	0,0573	6,5814	0,0089	0,0316
50-17	39,4521	0,0157		0,0002	126,177	0,3217	0,1451	48,7771	0,0186	0,0329
51-17	7,2717	0,0117		0,0001	62,0329	0,2807	0,0977	5,7497	0,0132	0,0273
52-17	5,7238	0,0060		0,0001	47,1980	0,2238	0,0570	4,3702	0,0062	0,0200
53-17	4,0197	0,0024		0,0001	75,0001	0,2203	0,0993	4,3702	0,0028	0,0106
54-17	6,8284	0,0015		0,0001	103,056	0,1513	0,1431	7,1468	0,0015	0,0106
55-17	13,4142	0,0045		0,0001	107,015	0,1531	0,0930	18,2148	0,0045	0,0116
56-17	3,1635	0,0034		0,0001	40,7667	0,1073	0,1132	4,3702	0,0029	0,0530
57-17	4,2392	0,0052		0,0001	42,7883	0,1882	0,1100	4,3702	0,0049	0,0309
58-17	4,6440	0,0056		0,0001	53,7604	0,1941	0,0865	4,3702	0,0058	0,0381
59-17	2,3619	0,0023		0,0001	38,0132	0,1133	0,1122	4,3702	0,0028	0,0191
60-17	1,4215	0,0012		0,0001	46,9204	0,0945	0,0834	4,3702	0,0014	0,0073
61-17	2,1156	0,0200		0,0001	59,2915	0,1511	0,0609	4,3702	0,0104	0,0162
62-17	6,3949	0,0028		0,0001	86,9852	0,1323	0,1092	11,0217	0,0024	0,0127
63-17	6,0369	0,0058		0,0002	113,113	1,1145	0,1049	10,3748	0,0064	0,0427
64-17	4,1980	0,0015		0,0001	97,5600	0,1975	0,0626	5,2935	0,0017	0,0159
65-17	8,9086	0,0024		0,0001	107,380	0,1281	0,0856	9,5325	0,0015	0,0350
66-17	7,5871	0,0010		0,0001	99,5074	0,0962	0,1026	7,0714	0,0013	0,0126
67-17	7,2290	0,0023		0,0001	82,3817	0,7363	0,1585	8,7203	0,0028	0,0941
68-17	6,9008	0,0079		0,0001	103,965	0,8199	0,1080	7,5621	0,0065	0,0170
69-17	8,5431	0,0033		0,0001	115,133	2,3897	0,0862	7,7761	0,0027	0,0125
70-17	6,7822	0,0010		0,0001	101,567	0,1216	0,0625	7,1351	0,0008	0,0103
71-17	18,6350	0,0030		0,0001	106,089	0,2081	0,0508	19,5554	0,0027	0,0155
1-18	6,6691	0,0017		0,0000	7,4823	0,0825	0,0378	8,1226	0,0015	0,0185
2-18	4,7847	0,0035		0,0001	7,6407	0,3186	0,1015	9,4043	0,0040	0,0156
3-18	6,0330	0,0126		0,0001	6,9662	0,1910	0,1331	9,4207	0,0034	0,0538
4-18	1,6908	0,0028		0,0000	3,5186	0,1173	0,0430	4,0317	0,0026	0,0154
5-18	2,4427	0,0025		0,0000	4,4014	0,1463	0,0966	4,9402	0,0028	0,0134
6-18	9,1353	0,0159		0,0002	15,3525	0,5956	0,1070	11,1766	0,0155	0,0624
7-18	8,5384	0,0095		0,0001	14,1142	0,3828	0,0789	11,5143	0,0091	0,0320
8-18	3,9655	0,0048		0,0001	6,3153	0,1846	0,1318	7,2094	0,0048	0,0185
9-18	6,2634	0,0111		0,0002	13,3774	0,3851	0,1136	11,2217	0,0096	0,0442
10-18	5,1685	0,0106		0,0001	7,1145	0,1636	0,1047	5,6587	0,0099	0,0173
11-18	6,4901	0,0063		0,0001	8,0639	0,3087	0,0997	9,7944	0,0047	0,0197
12-18	7,3284	0,0088		0,0001	9,1138	0,2738	0,0606	9,1593	0,0086	0,0317
13-18	5,3537	0,0056		0,0001	10,2764	0,2219	0,0741	10,6578	0,0047	0,0206

id	K	La	Li	Lu	Mg	Mn	Mo	Na	Nd	Ni
14-18	9,4086	0,0078		0,0001	9,3290	0,2430	0,1213	11,1197	0,0074	0,0234
15-18	15,2211	0,0144		0,0003	15,9922	0,6301	0,0844	15,0713	0,0147	0,0839
16-18	9,9331	0,0107		0,0001	13,3411	0,3396	0,1351	13,7741	0,0098	0,0514
17-18	17,3476	0,0245		0,0004	16,4574	0,4058	0,1109	11,1262	0,0203	0,0432
18-18	8,0891	0,0100		0,0001	9,9456	0,2998	0,0905	10,1364	0,0079	0,0245
19-18	3,1146	0,0045		0,0001	6,7843	0,1600	0,1050	8,0195	0,0046	0,0198
20-18	24,7500	0,0123		0,0001	22,3915	0,4351	0,1224	27,5482	0,0107	0,0275
21-18	7,8272	0,0128		0,0002	10,6851	0,5398	0,1063	9,2146	0,0148	0,0295
22-18	3,9603	0,0074		0,0001	11,1921	0,9521	0,2654	10,6916	0,0072	0,1331
23-18	9,2895	0,0118		0,0002	17,2749	0,4768	2,7180	13,1453	0,0114	0,0689
24-18	5,7008	0,0103		0,0001	13,9096	0,6155	0,1459	11,8395	0,0091	0,0659
25-18	5,8284	0,0029		0,0000	8,6254	0,2923	0,5185	10,2736	0,0024	0,0052
26-18	49,3404	0,0824		0,0007	51,3245	1,6439	0,1266	32,0181	0,0826	0,1663
27-18	152,5813	0,0008		0,0001	53,7258	0,0947	0,0535	191,2121	0,0009	0,0124
28-18	141,7452	0,0037		0,0001	85,6573	0,1217	0,1081	277,8809	0,0022	0,0092
29-18	237,6362	0,0040		0,0001	75,6883	0,1500	0,2439	330,3162	0,0039	0,0092
30-18	62,7044	0,0025		0,0001	43,0299	0,1141	0,1572	97,7406	0,0011	0,0591
31-18	223,9395	0,0005		0,0000	78,5940	0,0553	0,1044	326,7869	0,0003	0,0031
32-18	61,2734	0,0039		0,0001	41,8802	0,1216	0,1287	91,5388	0,0030	0,0175
33-18	127,5021	0,0029		0,0001	53,4611	0,1247	0,0947	181,9574	0,0040	0,0159
34-18	177,0432	0,0029		0,0000	67,8400	0,1042	0,0486	246,2359	0,0024	0,0031
35-18	189,9958	0,0013		0,0000	75,1189	0,1029	0,1511	265,5285	0,0009	0,0031
36-18	37,5431	0,0044		0,0001	23,1536	0,1060	0,1100	53,4216	0,0037	0,0087
37-18	177,7078	0,0053		0,0001	85,1029	0,1900	0,0958	268,7673	0,0044	0,0092
38-18	6,3405	0,0053		0,0001	23,9926	0,2371	0,2536	16,0051	0,0039	0,0047
39-18	743,4724	0,0009		0,0000	130,223	0,1191	0,0837	921,7145	0,0016	0,0031
40-18	44,8081	0,0014		0,0000	56,3472	0,1018	0,0571	77,3380	0,0013	0,0066
41-18	6,8400	0,0035		0,0003	53,1992	1,1098	0,2561	14,2374	0,0066	0,0675
42-18	13,4508	0,0006		0,0001	36,4505	0,0516	0,0830	26,9358	0,0002	0,0092

Table A22. Continuation of concentrations from all the samples (µg/g) from P to Sn. Empty cells means more than 50% of the concentrations were below LOD and discarded from the analysis.

id	P	Pb	Pr	Rb	S	Sb	Sc	Se	Si	Sm	Sn
72-17	308,3579	0,0046		0,3866	2595,1418			0,2011	10,1075		0,0039
73-17	187,5423	0,0205		0,6650	2186,9036			0,1845	10,9838		0,0069
74-17	543,7394	0,0025		0,8755	2120,1050			0,3244	9,5584		0,0033
75-17	693,5611	0,0025		1,3221	2081,3383			0,5108	6,2766		0,0019
76-17	917,0556	0,0010		1,6027	1667,5523			0,3965	3,2598		0,0012
77-17	810,7924	0,0025		0,9485	1502,2097			0,5041	1,8707		0,0005
78-17	928,1734	0,0023		4,1810	1738,7384			0,4505	4,0714		0,0006
79-17	878,3997	0,0031		2,1537	1800,1788			0,6768	4,1297		0,0006
80-17	865,1532	0,0014		1,3812	1646,5454			0,5360	3,9255		0,0005
81-17	998,6268	0,0023		2,1440	1747,0663			0,9041	2,7173		0,0004
82-17	924,4934	0,0056		1,8437	1667,7590			0,3992	4,4005		0,0006
83-17	940,6441	0,0028		1,5648	1769,6959			0,6479	3,2598		0,0002
84-17	717,5042	0,0034		1,5014	1700,5827			0,5536	4,1066		0,0011
85-17	816,5792	0,0019		1,5320	1632,3903			0,4135	3,8969		0,0011
86-17	392,1609	0,0843		0,6235	2615,1636			0,2156	7,2478		0,0034
87-17	430,8926	0,0025		0,7150	2128,3271			0,2568	15,8832		0,0025
88-17	843,1626	0,0018		2,2575	1716,2678			0,4152	4,3065		0,0008
89-17	708,0827	0,0025		1,0511	1895,7424			0,5731	7,4549		0,0014
90-17	765,2067	0,0031		0,7383	1810,6866			0,6863	11,6418		0,0015
91-17	795,2916	0,0015		0,9384	1397,3472			0,3575	2,3979		0,0005
92-17	838,8670	0,0016		1,1434	1651,5887			0,4560	1,4998		0,0006
93-17	982,9021	0,0068		1,5147	1983,8613			0,3740	3,2598		0,0010
94-17	1536,2500	0,0152		1,8559	2514,9304			0,4094	3,2598		0,0006
95-17	854,1822	0,0057		1,6755	2290,6068			0,3549	8,2837		0,0012
96-17	785,1016	0,0070		2,3894	2120,1350			0,3742	3,2598		0,0015
97-17	1132,0978	0,0100		3,5486	2061,6812			0,5100	3,2598		0,0007
98-17	906,9921	0,0095		1,6705	1837,4765			0,5395	3,2598		0,0009
99-17	850,1451	0,0100		1,4854	2248,8954			0,4608	3,2598		0,0015
100-17	1082,7423	0,0064		3,2743	1885,6326			0,4800	3,2598		0,0004
101-17	1263,5226	0,0504		3,0977	2142,5413			0,5992	3,2598		0,0007
102-17	887,7576	0,0036		1,2574	1890,9978			0,2962	3,6692		0,0016
103-17	1188,7774	0,0104		2,2097	1822,0218			0,4985	3,2598		0,0002
104-17	1155,8790	0,0175		1,8517	2190,6071			1,0294	4,6619		0,0007
43-18	988,6090	0,0048		1,3193	2018,2370			0,3127	7,0689		0,0000
44-18	869,7181	0,0139		1,5135	1773,3489			0,3389	6,8255		0,0000
45-18	905,0492	0,0216		2,2309	3149,8880			0,3620	36,9322		0,0000
46-18	990,7235	0,0048		1,7717	2019,4251			0,3586	8,7199		0,0000
48-18	695,4600	0,0064		1,5950	1363,3249			0,2236	9,4965		0,0000
49-18	530,4201	0,0057		1,5420	1551,6192			0,1437	4,0652		0,0000
50-18	817,2989	0,0116		2,0201	2067,3139			0,2681	5,4447		0,0000
51-18	787,3400	0,0033		1,8941	2160,7108			0,2757	6,0112		0,0000
52-18	1023,5615	0,0020		2,3580	2014,9386			0,3789	3,1319		0,0000
53-18	496,1181	0,0023		0,5307	2334,9757			0,2614	1,6370		0,0000
54-18	835,6632	0,0050		1,6147	1770,5664			0,3602	4,0641		0,0000
55-18	888,8493	0,0074		2,7347	1954,3830			0,3991	5,2103		0,0000
56-18	689,7045	0,0022		1,0244	2128,7317			0,2954	2,4883		0,0000
57-18	929,0383	0,0037		4,5121	1792,5236			0,3610	4,0517		0,0000
58-18	764,8050	0,0030		2,3430	1993,1825			0,2202	9,4081		0,0000
59-18	871,4647	0,0045		2,4996	1973,2228			0,3888	7,1344		0,0000
61-18	890,2871	0,0019		2,1372	1789,3146			0,4512	4,6473		0,0007
62-18	802,6714	0,0030		1,3493	1682,1962			0,3731	4,9491		0,0000
63-18	1018,4670	0,0023		2,9112	1522,4940			0,5092	8,6834		0,0000
64-18	892,8368	0,0019		4,0068	1675,9294			0,3576	7,4557		0,0000
65-18	899,0122	0,0033		1,2819	1820,9353			0,6109	7,4923		0,0000
66-18	566,5518	0,0026		0,6190	1623,7576			0,3154	5,4963		0,0000
67-18	975,5668	0,0030		2,2300	1790,2096			0,5125	4,4342		0,0000
68-18	666,0319	0,0013		2,2050	1878,8719			0,3338	7,4951		0,0000
69-18	1051,5797	0,0047		0,8346	1609,5540			0,9173	3,5950		0,0000
70-18	858,2312	0,0018		2,2896	1609,8800			0,4295	5,5884		0,0000
71-18	825,9430	0,0053		1,6002	1638,4593			0,5813	4,8877		0,0000
72-18	761,9610	0,0058		1,5226	1529,3934			0,5385	4,9158		0,0000
73-18	912,1335	0,0017		4,2019	1670,6965			0,2932	5,9477		0,0000
74-18	719,2143	0,0043		2,5567	1626,4714			0,2959	5,4375		0,0000
1-16	73,3578	0,0172	0,0003	0,0056	26078,6875	0,0044	0,0008	1,1934	12,0382	0,0004	0,0073
2-16	80,3734	0,0207	0,0005	0,0098	24726,8017	0,0118	0,0025	1,3053	26,2965	0,0004	0,0667
3-16	94,0958	0,0114	0,0011	0,0178	25350,5029	0,0063	0,0025	1,2301	34,1483	0,0015	0,0092
4-16	91,2614	0,0086	0,0004	0,0098	24740,6187	0,0118	0,0025	1,2204	16,8983	0,0004	0,0029
5-16	74,8670	0,0295	0,0023	0,0464	25466,5618	0,0059	0,0074	1,1238	60,1237	0,0020	0,0089
6-16	70,1224	0,0240	0,0011	0,0116	25573,1967	0,0204	0,0025	1,0926	21,3983	0,0009	0,0052
7-16	66,1334	0,0402	0,0012	0,0238	26665,5675	0,0042	0,0035	1,1446	29,5690	0,0010	0,0099
8-16	72,8966	0,0214	0,0009	0,0167	25771,2811	0,0084	0,0016	1,5741	27,4557	0,0007	0,0065
9-16	69,9927	0,0212	0,0006	0,0045	25946,0718	0,0036	0,0008	1,7124	12,7990	0,0002	0,0120
10-16	66,9426	0,0277	0,0015	0,0365	24594,8794	0,0059	0,0053	1,2719	53,1344	0,0018	0,0210
11-16	72,2000	0,0773	0,0014	0,0406	27105,8695	0,0482	0,0025	1,4322	26,5500	0,0012	0,0034
12-16	86,2258	0,0261	0,0015	0,0345	26697,4936	0,0081	0,0026	1,2806	35,0050	0,0013	0,0045
13-16	21,0210	0,0047	0,0007	0,0031	7789,1591	0,0021	0,0008	0,3187	6,7309	0,0003	0,0016
14-16	74,1233	0,1273	0,0349	0,5669	26604,9900	0,0354	0,0953	0,9915	693,8445	0,0286	0,0179
15-16	110,4086	0,2650	0,0951	1,0792	24739,4246	0,0168	0,3322	1,3942	1806,676	0,0719	0,0521
16-16	83,0414	0,0384	0,0026	0,0245	25969,8306	0,0124	0,0059	1,4083	48,3553	0,0022	0,0328
17a-16	66,7272	0,0203	0,0008	0,0097	25204,1680	0,0055	0,0014	1,1543	13,5294	0,0007	0,0030
17b-16	68,0595	0,0228	0,0010	0,0196	25732,9364	0,0069	0,0018	1,1851	25,1293	0,0007	0,0041
18-16	74,3286	0,0220	0,0005	0,0062	25104,8488	0,0048	0,0021	1,2857	23,8342	0,0006	0,0087
19-16	73,4530	0,0159	0,0005	0,0102	26082,1129	0,0060	0,0020	1,8126	23,1117	0,0004	0,0062
1-17	74,3187	0,0414	0,0009	0,0138	26488,5361	0,0113	0,0022	1,0532	23,0861	0,0008	0,0534

id	P	Pb	Pr	Rb	S	Sb	Sc	Se	Si	Sm	Sn
2-17	78,1728	0,0642	0,0018	0,0319	26295,2978	0,0053	0,0054	1,6097	48,6309	0,0010	0,0132
3-17	85,1723	0,0705	0,0042	0,0551	25174,8788	0,0085	0,0075	1,0732	77,5459	0,0029	0,0175
4-17	83,8740	0,0619	0,0041	0,0513	26454,4616	0,0102	0,0090	1,0446	69,1772	0,0030	0,0170
5-17	100,0315	0,1061	0,0031	0,0411	26955,5992	0,0245	0,0062	1,0171	65,6121	0,0019	0,0122
6-17	81,5532	0,1040	0,0110	0,1746	26162,6224	0,0416	0,0293	1,0830	338,8056	0,0084	0,0321
7-17	124,4032	0,0452	0,0021	0,0234	26217,3987	0,0072	0,0054	1,3317	42,1472	0,0012	0,0115
8-17	93,7494	0,0943	0,0038	0,0660	27316,2720	0,0208	0,0123	1,2000	103,2853	0,0029	0,0291
9-17	76,3037	0,0639	0,0040	0,0561	26448,5496	0,0136	0,0077	1,1525	67,8556	0,0032	0,0110
10-17	75,7158	0,0735	0,0023	0,0346	26440,3602	0,0077	0,0066	0,9108	57,7472	0,0015	0,0127
11-17	87,5505	0,2172	0,0051	0,0384	26520,6600	0,0114	0,0084	0,9791	75,8569	0,0035	0,0336
12-17	106,2934	2,5651	0,0024	0,0621	28162,5617	0,0138	0,0061	0,9006	59,2517	0,0020	0,3236
13-17	93,0440	0,0451	0,0030	0,0501	26869,3666	0,0091	0,0060	1,3094	56,7875	0,0022	0,0120
14-17	91,7823	0,1002	0,0078	0,1006	27117,6710	0,0106	0,0101	1,2811	115,0149	0,0059	0,0362
15-17	79,9862	0,0768	0,0120	0,1957	26172,8448	0,0159	0,0217	0,9144	194,0533	0,0090	0,0274
16-17	80,8238	0,0789	0,0079	0,1206	26610,9625	0,0093	0,0137	1,1094	134,5950	0,0057	0,0222
17-17	76,4648	0,1082	0,0053	0,0518	26260,0220	0,0166	0,0070	1,2802	72,6675	0,0037	0,0291
18-17	96,2437	0,1155	0,0026	0,0603	26266,8251	0,0069	0,0025	1,2818	28,6068	0,0015	0,0183
19-17	104,7649	0,1291	0,0044	0,0871	26476,7572	0,0096	0,0074	1,2634	83,1125	0,0033	0,0302
20-17	94,4683	0,1331	0,0113	0,1632	26267,9642	0,0156	0,0170	1,0698	160,7463	0,0087	0,0350
21-17	101,2289	0,1060	0,0026	0,0357	26676,2801	0,0074	0,0078	1,5469	65,9422	0,0021	0,0133
22-17	89,5396	0,0925	0,0044	0,0578	24452,5099	0,0144	0,0086	0,8042	75,1897	0,0038	0,0194
23-17	75,3123	0,0859	0,0042	0,0790	22813,8180	0,0111	0,0088	0,9915	78,4122	0,0032	0,0184
24-17	72,2671	0,0587	0,0020	0,0278	22459,5242	0,0057	0,0038	0,8360	33,2033	0,0017	0,0075
25-17	85,0097	0,1791	0,0077	0,0425	25809,1382	0,0121	0,0155	1,0904	87,1984	0,0060	0,0242
26-17	118,0229	0,2821	0,0079	0,1014	24820,6899	0,0170	0,0187	1,2600	247,1749	0,0062	0,0968
27-17	468,0561	0,0136	0,0026	0,1018	24287,9793	0,0083	0,0044	1,8956	46,8508	0,0023	0,0120
28-17	354,4247	0,0167	0,0023	0,0568	24811,8175	0,0073	0,0048	1,7898	46,4460	0,0016	0,0127
29-17	292,6566	0,0105	0,0008	0,0170	23488,8418	0,0066	0,0015	1,5516	16,6335	0,0004	0,0096
30-17	362,0112	0,0079	0,0006	0,0546	23790,7184	0,0043	0,0015	1,6630	12,4102	0,0004	0,0056
31-17	525,3520	0,0099	0,0008	0,1406	23059,4232	0,0054	0,0015	2,0563	16,2763	0,0005	0,0056
32-17	488,2685	0,0274	0,0010	0,0206	22875,3867	0,0119	0,0023	1,0003	45,9727	0,0011	0,0058
33-17	594,9262	0,0078	0,0008	0,0680	22505,9213	0,0117	0,0016	1,1566	23,9511	0,0006	0,0065
34-17	540,6408	0,0062	0,0003	0,0094	22630,7019	0,0127	0,0006	1,1172	11,4402	0,0005	0,0045
35-17	447,7051	0,0179	0,0004	0,0084	22987,7178	0,0107	0,0023	1,6853	14,8292	0,0002	0,0057
36-17	463,3600	0,0102	0,0012	0,0344	23350,0907	0,0125	0,0023	1,5948	23,3258	0,0010	0,0043
37-17	434,0006	0,0051	0,0003	0,0105	22986,6751	0,0137	0,0009	1,4095	12,4615	0,0002	0,0064
38-17	339,4241	0,0093	0,0018	0,0391	22740,8459	0,0092	0,0031	1,6449	43,7666	0,0017	0,0046
39-17	451,7817	0,0086	0,0013	0,0733	22322,9178	0,0080	0,0034	1,8553	36,2013	0,0012	0,0066
40-17	343,7578	0,0095	0,0014	0,0138	21384,0264	0,0104	0,0025	1,8895	25,2790	0,0022	0,0097
41-17	491,6831	0,0089	0,0028	0,0266	24410,2623	0,0115	0,0053	1,2585	57,9354	0,0019	0,0040
42-17	462,5138	0,0072	0,0007	0,0140	24361,2201	0,0130	0,0015	1,3502	26,9853	0,0005	0,0056
43-17	497,0323	0,0098	0,0012	0,0142	23687,4232	0,0104	0,0026	1,2830	28,0001	0,0008	0,0365
44-17	520,1955	0,0099	0,0023	0,0195	22715,8853	0,0116	0,0061	1,2259	44,7612	0,0018	0,0079
45-17	454,5605	0,0068	0,0005	0,0157	23049,4658	0,0065	0,0015	1,4131	22,9560	0,0003	0,0061
46-17	509,1493	0,0090	0,0003	0,0074	22999,8080	0,0080	0,0006	1,4414	7,9356	0,0002	0,0718
47-17	791,9107	0,0092	0,0002	0,0164	22398,3005	0,0068	0,0011	1,7127	9,2452	0,0003	0,0111
48-17	701,9476	0,0287	0,0029	0,0266	22841,2525	0,0093	0,0030	1,5210	42,5091	0,0028	0,0240
49-17	446,8319	0,0138	0,0023	0,0442	24501,3101	0,0089	0,0046	1,2618	62,0401	0,0017	0,0193
50-17	582,9588	0,0193	0,0045	0,1049	25537,0645	0,0067	0,0078	1,2623	74,4299	0,0042	0,0105
51-17	390,4004	0,0292	0,0032	0,0419	25382,2027	0,0128	0,0066	1,2558	61,9273	0,0030	0,0240
52-17	424,6870	0,0128	0,0017	0,0289	24234,3183	0,0221	0,0032	1,6069	45,4281	0,0013	0,0086
53-17	528,2320	0,0083	0,0006	0,0172	24660,0960	0,0112	0,0015	1,6268	20,3972	0,0005	0,0033
54-17	567,4737	0,0090	0,0004	0,0169	24980,0585	0,0086	0,0015	1,9859	18,6756	0,0006	0,0037
55-17	551,2017	0,0103	0,0012	0,0247	25298,8908	0,0171	0,0023	2,0332	24,2431	0,0009	0,0057
56-17	322,2745	0,0117	0,0007	0,0126	25543,7985	0,0142	0,0015	1,5331	19,8379	0,0006	0,0044
57-17	354,7606	0,0101	0,0012	0,0218	25058,1452	0,0149	0,0033	1,6782	37,6331	0,0010	0,0067
58-17	408,5670	0,0137	0,0014	0,0238	25457,7900	0,0150	0,0034	1,8478	38,0813	0,0011	0,0054
59-17	388,8409	0,0083	0,0008	0,0080	24408,2231	0,0076	0,0021	1,3362	20,4409	0,0009	0,0184
60-17	396,9269	0,0041	0,0003	0,0058	24457,1384	0,0059	0,0015	1,2706	12,3884	0,0003	0,0035
61-17	495,5546	0,0099	0,0033	0,0079	23726,3056	0,0039	0,0025	1,1626	20,0814	0,0011	0,0070
62-17	469,2967	0,0083	0,0005	0,0172	24676,1898	0,0035	0,0015	1,0401	15,4584	0,0006	0,0077
63-17	615,5339	0,0163	0,0014	0,0239	23522,6440	0,0072	0,0141	1,1645	103,8489	0,0022	0,0090
64-17	619,2165	0,0053	0,0004	0,0138	23169,5865	0,0045	0,0015	1,2174	20,8217	0,0006	0,0030
65-17	414,9735	0,0121	0,0006	0,0357	24557,2610	0,0084	0,0015	1,7286	16,1802	0,0002	0,0034
66-17	364,4583	0,0093	0,0003	0,0289	24717,1850	0,0102	0,0015	1,8225	6,3559	0,0003	0,0032
67-17	352,3911	0,0108	0,0006	0,0284	25300,1461	0,0133	0,0015	1,8753	17,9971	0,0005	0,0048
68-17	471,8115	0,0132	0,0018	0,0243	24447,9722	0,0150	0,0015	1,9706	22,5184	0,0010	0,0044
69-17	517,6474	0,0202	0,0007	0,0430	23893,6467	0,0035	0,0022	1,1834	61,9420	0,0006	0,0034
70-17	430,6495	0,0059	0,0002	0,0387	25370,3609	0,0032	0,0015	1,1680	10,2745	0,0002	0,0049
71-17	377,6919	0,0196	0,0006	0,1154	24456,1938	0,0057	0,0015	1,2659	21,2224	0,0005	0,0057
1-18	39,4996	0,0090	0,0004	0,0193	10480,3005	0,0031	0,0008	0,4078	15,7352	0,0004	0,0037
2-18	70,3058	0,0286	0,0012	0,0157	24431,4534	0,0099	0,0011	1,1257	51,2738	0,0010	0,0110
3-18	74,3445	0,0325	0,0010	0,0206	25224,0568	0,0100	0,0004	0,9826	46,5934	0,0012	0,0117
4-18	30,4369	0,0216	0,0006	0,0070	12158,5777	0,0088	0,0002	0,4948	18,1846	0,0005	0,0059
5-18	60,4487	0,0183	0,0006	0,0081	23453,9564	0,0062	0,0012	1,0397	18,1887	0,0005	0,0031
6-18	75,1498	0,0494	0,0039	0,0423	24322,1450	0,0166	0,0011	1,0156	99,7194	0,0033	0,0188
7-18	82,0160	0,0392	0,0021	0,0367	22813,7449	0,0823	0,0015	1,3266	78,4788	0,0016	0,0221
8-18	68,9980	0,0272	0,0011	0,0197	23648,2420	0,0069	0,0004	1,1453	30,5995	0,0007	0,0069
9-18	69,6299	0,1380	0,0026	0,0325	24177,6614	0,0126	0,0002	1,0356	82,9718	0,0024	0,0137
10-18	70,4708	0,0205	0,0027	0,0294	22349,0572	0,0027	0,0004	1,1230	46,7512	0,0019	0,0109
11-18	73,0907	0,0239	0,0012	0,0205	24483,4313	0,0072	0,0004	1,0116	38,0055	0,0008	0,0055
12-18	76,5345	0,0740	0,0021	0,0360	25416,3147	0,0145	0,0002	1,5875	56,6990	0,0020	0,0177
13-18	72,0018	0,0249	0,0012	0,0192	23962,5079	0,0069	0,0002	1,1007	41,6558	0,0009	0,0094
14-18	74,8168	0,0220	0,0018	0,0414	24751,6514	0,0065	0,0004	1,3283	46,0520	0,0015	0,0093
15-18	83,9518	0,0292	0,0037	0,0584	24553,2342	0,0115	0,0031	1,2559	73,0757	0,0035	0,0152
16-18	70,9415	0,0295	0,0026	0,0461	24797,6314	0,0093	0,0004	0,8698	61,3402	0,0023	0,0118
17-18	71,6272	0,0941	0,0051	0,0943	24296,3690	0,0132	0,0022	1,1622	134,6043	0,0040	0,0383
18-18	74,4423	0,0464	0,0023	0,0382	24567,3245	0,0064	0,0009	1,1549	58,9139	0,0011	0,0056

id	P	Pb	Pr	Rb	S	Sb	Sc	Se	Si	Sm	Sn
19-18	71,7961	0,0222	0,0010	0,0119	24541,0804	0,0071	0,0004	1,1806	32,7473	0,0005	0,0072
20-18	120,6373	0,0596	0,0028	0,0942	25377,5049	0,0091	0,0002	1,5518	231,8108	0,0018	0,0220
21-18	88,2526	0,0490	0,0033	0,0426	24043,1464	0,0048	0,0010	1,1576	59,7869	0,0021	0,0094
22-18	76,8872	0,0449	0,0018	0,0202	24806,8192	0,0081	0,0009	1,8170	47,3451	0,0016	0,0095
23-18	77,3603	0,0758	0,0029	0,0526	23926,7190	0,0054	0,0013	1,0459	91,6578	0,0024	0,0122
24-18	81,5400	0,0518	0,0024	0,0263	25109,1130	0,0100	0,0002	1,2335	56,2023	0,0018	0,0149
25-18	72,8256	0,0234	0,0005	0,0220	24225,7007	0,0057	0,0004	1,3713	19,8671	0,0004	0,0081
26-18	104,9917	0,0977	0,0209	0,2613	23968,6153	0,0047	0,0092	1,4569	281,9315	0,0161	0,0125
27-18	458,9007	0,0036	0,0003	0,3038	12575,9041	0,0040	0,0110	0,6494	36,6365	0,0004	0,0034
28-18	564,4701	0,0033	0,0014	0,3268	22504,1816	0,0030	0,0268	0,4827	192,5622	0,0022	0,0119
29-18	794,1219	0,0153	0,0011	0,3605	24956,7136	0,0126	0,0011	1,2385	37,7893	0,0004	0,0056
30-18	438,8474	0,0082	0,0008	0,1052	19011,1834	0,0043	0,0044	0,7879	92,5551	0,0009	0,0265
31-18	703,5977	0,0034	0,0001	1,0236	24562,1488	0,0020	0,0004	0,8759	7,0865	0,0003	0,0029
32-18	420,3665	0,0077	0,0008	0,1003	23676,1968	0,0086	0,0004	1,4753	49,3681	0,0008	0,0033
33-18	519,0737	0,0057	0,0008	0,1160	23783,3548	0,0135	0,0004	1,4859	25,7903	0,0014	0,0050
34-18	670,5475	0,0050	0,0007	0,4106	23513,7370	0,0065	0,0004	1,4313	21,2521	0,0008	0,0026
35-18	654,0267	0,0027	0,0005	0,9091	24496,7599	0,0053	0,0004	1,0626	12,8318	0,0003	0,0016
36-18	240,1473	0,0105	0,0009	0,0524	25452,5832	0,0103	0,0004	1,4953	50,4939	0,0003	0,0045
37-18	752,1836	0,0086	0,0012	0,3924	22697,1569	0,0106	0,0011	1,2597	49,9691	0,0012	0,0037
38-18	223,8788	0,0081	0,0013	0,0288	24628,7354	0,0064	0,0004	1,6585	37,2190	0,0010	0,0045
39-18	1267,1660	0,0048	0,0003	3,2462	22030,9917	0,0025	0,0004	0,9610	20,4119	0,0005	0,0021
40-18	634,5103	0,0041	0,0003	0,1650	22803,1488	0,0021	0,0002	1,2706	12,1064	0,0004	0,0030
41-18	403,4733	0,0127	0,0013	0,0262	24888,3635	0,0102	0,0066	1,1381	163,7150	0,0026	0,0093
42-18	479,9392	0,0037	0,0002	0,0303	23597,5633	0,0036	0,0011	1,1381	26,8021	0,0004	0,0084

Table A23. Continuation of concentrations from all the samples (µg/g) from Sr to Zn. Empty cells means more than 50% of the concentrations were below LOD and discarded from the analysis.

id	Sr	Tb	Th	Ti	Tl	U	V	W	Y	Yb	Zn
72-17	0,0364		0,0003	0,0154	0,0001	0,0002	0,0026		0,0512		1,7732
73-17	0,0320		0,0003	0,0367	0,0001	0,0000	0,0031		0,0087		1,7588
74-17	0,0338		0,0000	0,0034	0,0002	0,0001	0,0025		0,0017		2,7280
75-17	0,0234		0,0002	0,0034	0,0002	0,0001	0,0017		0,0008		3,3023
76-17	0,0218		0,0001	0,0034	0,0003	0,0000	0,0011		0,0022		4,4180
77-17	0,0234		0,0000	0,0008	0,0001	0,0000	0,0006		0,0001		3,5991
78-17	0,0349		0,0000	0,0008	0,0002	0,0000	0,0007		0,0001		3,8906
79-17	0,0327		0,0000	0,0008	0,0001	0,0000	0,0007		0,0003		4,2832
80-17	0,0287		0,0000	0,0008	0,0001	0,0000	0,0005		0,0001		3,8304
81-17	0,0209		0,0000	0,0016	0,0002	0,0000	0,0008		0,0001		4,3507
82-17	0,0256		0,0000	0,0016	0,0001	0,0000	0,0025		0,0002		3,6061
83-17	0,0331		0,0000	0,0034	0,0001	0,0000	0,0022		0,0012		4,1825
84-17	0,0234		0,0000	0,0016	0,0001	0,0000	0,0007		0,0002		3,2229
85-17	0,0408		0,0000	0,0016	0,0001	0,0000	0,0012		0,0001		3,6875
86-17	0,0309		0,0001	0,0034	0,0001	0,0002	0,0027		0,0009		2,0831
87-17	0,0322		0,0001	0,0034	0,0001	0,0001	0,0024		0,0003		2,2238
88-17	0,0234		0,0000	0,0016	0,0002	0,0000	0,0010		0,0001		3,7903
89-17	0,0271		0,0000	0,0109	0,0002	0,0001	0,0014		0,0001		3,2796
90-17	0,0219		0,0000	0,0016	0,0001	0,0001	0,0017		0,0001		3,4702
91-17	0,0245		0,0000	0,0008	0,0001	0,0000	0,0010		0,0000		3,3479
92-17	0,0263		0,0000	0,0069	0,0001	0,0000	0,0008		0,0001		3,7931
93-17	0,0159		0,0000	0,0152	0,0000	0,0000	0,0054		0,0002		3,0670
94-17	0,0099		0,0000	0,0034	0,0000	0,0000	0,0177		0,0001		4,7116
95-17	0,0179		0,0000	0,0034	0,0001	0,0001	0,0030		0,0002		3,2620
96-17	0,0173		0,0000	0,0151	0,0000	0,0001	0,0024		0,0002		2,8106
97-17	0,0140		0,0000	0,0034	0,0001	0,0000	0,0019		0,0006		3,7548
98-17	0,0135		0,0000	0,0034	0,0001	0,0000	0,0019		0,0001		3,2886
99-17	0,0181		0,0000	0,0034	0,0001	0,0001	0,0045		0,0002		3,0468
100-17	0,0199		0,0000	0,0034	0,0001	0,0000	0,0034		0,0001		3,6484
101-17	0,0147		0,0000	0,0264	0,0001	0,0000	0,0030		0,0001		3,6861
102-17	0,0194		0,0000	0,0016	0,0000	0,0000	0,0030		0,0001		3,3766
103-17	0,0149		0,0000	0,0034	0,0001	0,0000	0,0051		0,0005		3,8703
104-17	0,0095		0,0000	0,0036	0,0001	0,0000	0,0020		0,0000		3,3163
43-18	0,0285		0,0002	0,0119	0,0001	0,0001	0,0731		0,0001		3,9554
44-18	0,0247		0,0004	0,1123	0,0001	0,0002	0,0047		0,0008		2,8424
45-18	0,0788		0,0017	0,9472	0,0002	0,0008	0,0339		0,0049		4,3435
46-18	0,0273		0,0002	0,0978	0,0001	0,0001	0,0065		0,0003		4,0913
48-18	0,0338		0,0003	0,1335	0,0002	0,0001	0,0073		0,0008		2,6886
49-18	0,0347		0,0011	0,3803	0,0001	0,0001	0,0110		0,0014		2,1798
50-18	0,0493		0,0003	0,0183	0,0000	0,0001	0,0044		0,0004		3,5365
51-18	0,0254		0,0002	0,1274	0,0000	0,0001	0,0030		0,0003		2,8457
52-18	0,0173		0,0001	0,0065	0,0000	0,0000	0,0008		0,0001		3,5265
53-18	0,0177		0,0004	0,0164	0,0001	0,0001	0,0028		0,0002		1,7047
54-18	0,0147		0,0001	0,0227	0,0001	0,0001	0,0035		0,0003		2,6480
55-18	0,0158		0,0001	0,0071	0,0000	0,0000	0,0030		0,0001		3,0627
56-18	0,0158		0,0002	0,0882	0,0001	0,0001	0,0023		0,0006		2,4354
57-18	0,0224		0,0001	0,0230	0,0000	0,0001	0,0049		0,0002		3,1623
58-18	0,0194		0,0001	0,0115	0,0000	0,0001	0,0012		0,0002		2,9176
59-18	0,0157		0,0001	0,0132	0,0000	0,0001	0,0019		0,0002		2,7985
61-18	0,0321		0,0002	0,0106	0,0001	0,0001	0,0011		0,0002		3,9548
62-18	0,0298		0,0001	0,0122	0,0002	0,0000	0,0040		0,0001		3,3517
63-18	0,0243		0,0002	0,0616	0,0003	0,0001	0,0020		0,0005		4,3165
64-18	0,0293		0,0001	0,0104	0,0002	0,0001	0,0015		0,0002		3,9476

id	Sr	Tb	Th	Ti	Tl	U	V	W	Y	Yb	Zn
65-18	0,0259		0,0001	0,0266	0,0001	0,0000	0,0027		0,0002		3,9396
66-18	0,0260		0,0001	0,0068	0,0001	0,0001	0,0029		0,0001		2,8153
67-18	0,0222		0,0001	0,0041	0,0002	0,0000	0,0024		0,0001		4,1077
68-18	0,0293		0,0001	0,0157	0,0001	0,0001	0,2196		0,0003		3,0879
69-18	0,0258		0,0000	0,0020	0,0001	0,0000	0,0017		0,0000		4,2137
70-18	0,0349		0,0001	0,0134	0,0002	0,0000	0,0008		0,0001		4,3049
71-18	0,0268		0,0001	0,0124	0,0001	0,0000	0,0016		0,0001		3,5948
72-18	0,0293		0,0001	0,0047	0,0001	0,0000	0,0008		0,0001		3,3175
73-18	0,0542		0,0000	0,0090	0,0001	0,0000	0,0003		0,0008		4,0244
74-18	0,0290		0,0001	0,0217	0,0002	0,0001	0,0015		0,0001		3,1340
1-16	0,0435	0,0000	0,0004	0,4314	0,0009	0,0002	0,0107	0,0015	0,0020	0,0002	12,7311
2-16	0,0266	0,0001	0,0008	0,6176	0,0005	0,0005	0,0158	0,0024	0,0020	0,0003	6,2294
3-16	0,0204	0,0001	0,0014	0,6123	0,0005	0,0006	0,0207	0,0012	0,0032	0,0003	8,8864
4-16	0,0204	0,0001	0,0011	0,3432	0,0003	0,0006	0,0175	0,0018	0,0020	0,0003	7,7011
5-16	0,0455	0,0003	0,0052	2,0983	0,0004	0,0011	0,0578	0,0028	0,0068	0,0009	6,7461
6-16	0,0307	0,0001	0,0019	1,3965	0,0002	0,0010	0,0197	0,0010	0,0026	0,0004	6,8962
7-16	0,0251	0,0001	0,0028	0,7869	0,0004	0,0006	0,0271	0,0028	0,0031	0,0005	6,6395
8-16	0,0258	0,0001	0,0018	0,6631	0,0002	0,0004	0,0156	0,0043	0,0020	0,0006	10,4105
9-16	0,0334	0,0000	0,0008	0,3694	0,0003	0,0004	0,0057	0,0018	0,0012	0,0002	9,9808
10-16	0,0765	0,0001	0,0024	1,2820	0,0004	0,0005	0,0343	0,0122	0,0041	0,0007	7,8272
11-16	0,2814	0,0002	0,0010	0,7074	0,0104	0,0018	0,0243	0,0025	0,0037	0,0003	50,2825
12-16	0,0438	0,0002	0,0025	0,9017	0,0033	0,0007	0,0381	0,0065	0,0042	0,0004	7,5888
13-16	0,0066	0,0000	0,0005	0,1444	0,0001	0,0001	0,0085	0,0179	0,0017	0,0001	2,7334
14-16	0,7204	0,0042	0,0513	27,2283	0,0039	0,0118	0,7347	0,0060	0,1295	0,0129	8,1429
15-16	4,3397	0,0099	0,1453	68,1994	0,0066	0,0426	2,3566	0,1036	0,3008	0,0301	7,0952
16-16	0,1659	0,0002	0,0074	12,3338	0,0003	0,0009	0,0355	0,0054	0,0057	0,0007	8,5545
17a-16	0,0552	0,0001	0,0013	0,3662	0,0005	0,0004	0,0141	0,0014	0,0029	0,0003	13,8345
17b-16	0,0437	0,0001	0,0020	0,5077	0,0003	0,0004	0,0194	0,0014	0,0023	0,0003	11,0007
18-16	0,0284	0,0001	0,0007	0,7447	0,0004	0,0002	0,0243	0,0018	0,0023	0,0003	11,4084
19-16	0,0298	0,0001	0,0011	0,5105	0,0001	0,0005	0,0155	0,0018	0,0021	0,0003	7,4161
1-17	0,0360	0,0001	0,0009	1,3613	0,0003	0,0004	0,0313	0,0047	0,0055	0,0005	9,6995
2-17	0,0924	0,0002	0,0018	1,6804	0,0010	0,0009	0,0519	0,0079	0,0062	0,0008	14,2593
3-17	0,1347	0,0004	0,0060	3,6840	0,0010	0,0027	0,0781	0,0171	0,0131	0,0012	10,3466
4-17	0,1042	0,0004	0,0048	2,4728	0,0007	0,0018	0,0793	0,0070	0,0128	0,0011	12,7413
5-17	0,0849	0,0003	0,0029	1,8563	0,0004	0,0025	0,0585	0,0069	0,0119	0,0008	10,2098
6-17	0,9092	0,0011	0,0133	8,1207	0,0016	0,0079	0,2729	0,0354	0,0334	0,0037	13,5202
7-17	0,1002	0,0002	0,0025	1,2155	0,0003	0,0013	0,0378	0,0030	0,0070	0,0006	9,5789
8-17	0,3692	0,0005	0,0052	4,1400	0,0005	0,0018	0,1075	0,0214	0,0144	0,0014	6,9304
9-17	0,0775	0,0003	0,0044	2,1180	0,0005	0,0026	0,0738	0,0053	0,0095	0,0011	6,2764
10-17	0,0711	0,0003	0,0029	1,8182	0,0004	0,0012	0,0702	0,0150	0,0075	0,0009	9,1701
11-17	0,1292	0,0005	0,0042	2,4317	0,0011	0,0020	0,0800	0,0120	0,0157	0,0014	13,2608
12-17	0,0746	0,0003	0,0035	1,8004	0,0004	0,0019	0,0607	0,0063	0,0077	0,0009	16,2728
13-17	0,0790	0,0003	0,0040	1,8940	0,0004	0,0045	0,0663	0,0074	0,0091	0,0008	7,7319
14-17	0,1261	0,0007	0,0089	4,1963	0,0008	0,0039	0,1091	0,0169	0,0227	0,0026	6,9718
15-17	0,2141	0,0010	0,0136	6,8706	0,0024	0,0055	0,1941	0,0394	0,0320	0,0030	12,2552
16-17	0,1494	0,0008	0,0094	4,6740	0,0010	0,0048	0,1360	0,0084	0,0245	0,0024	10,7496
17-17	0,1212	0,0005	0,0055	2,5921	0,0006	0,0024	0,0662	0,0132	0,0131	0,0012	9,7437
18-17	0,1383	0,0002	0,0033	1,0898	0,0009	0,0009	0,0300	0,0050	0,0040	0,0004	17,6280
19-17	0,1385	0,0004	0,0061	2,6962	0,0006	0,0021	0,0681	0,0142	0,0125	0,0015	8,4300
20-17	0,1525	0,0010	0,0136	4,8080	0,0014	0,0059	0,1628	0,0221	0,0251	0,0022	12,5409
21-17	0,0802	0,0003	0,0035	2,0846	0,0004	0,0018	0,0691	0,0362	0,0090	0,0009	5,2698
22-17	0,1631	0,0005	0,0044	2,5314	0,0007	0,0038	0,0970	0,0226	0,0137	0,0012	19,8725
23-17	0,2926	0,0005	0,0054	2,7109	0,0021	0,0037	0,0935	0,0103	0,0126	0,0016	31,4997
24-17	0,1496	0,0002	0,0020	1,3122	0,0006	0,0008	0,0390	0,0034	0,0061	0,0006	20,0403
25-17	0,2050	0,0009	0,0061	3,2545	0,0009	0,0045	0,1088	0,0125	0,0249	0,0023	13,7652
26-17	1,2435	0,0009	0,0080	4,9553	0,0024	0,0048	0,1752	0,0111	0,0259	0,0026	31,8580
27-17	0,0951	0,0002	0,0028	1,3778	0,0033	0,0010	0,0373	0,0034	0,0067	0,0007	29,0747
28-17	0,0667	0,0002	0,0025	1,4012	0,0013	0,0007	0,0396	0,0025	0,0059	0,0004	25,8098
29-17	0,0459	0,0001	0,0010	0,5380	0,0009	0,0003	0,0159	0,0010	0,0027	0,0002	20,0651
30-17	0,0472	0,0001	0,0006	0,6467	0,0018	0,0002	0,0125	0,0015	0,0015	0,0002	22,4237
31-17	0,0712	0,0001	0,0008	0,6065	0,0036	0,0004	0,0142	0,0015	0,0028	0,0003	33,5029
32-17	0,1042	0,0002	0,0012	0,6714	0,0004	0,0004	0,0215	0,0069	0,0056	0,0005	27,9983
33-17	0,1020	0,0001	0,0009	0,8008	0,0014	0,0003	0,0170	0,0112	0,0030	0,0002	34,7876
34-17	0,0620	0,0001	0,0006	0,3341	0,0007	0,0002	0,0156	0,0129	0,0027	0,0003	25,6658
35-17	0,0648	0,0000	0,0006	0,4329	0,0011	0,0002	0,0112	0,0026	0,0015	0,0002	27,5229
36-17	0,0628	0,0002	0,0013	0,7182	0,0016	0,0003	0,0200	0,0013	0,0037	0,0003	24,0409
37-17	0,1901	0,0001	0,0010	0,3406	0,0009	0,0002	0,0113	0,0023	0,0019	0,0002	23,4159
38-17	0,0828	0,0002	0,0024	1,5988	0,0008	0,0007	0,0419	0,0061	0,0060	0,0006	22,4407
39-17	0,0866	0,0001	0,0017	0,9697	0,0016	0,0005	0,0308	0,0012	0,0047	0,0004	40,7053
40-17	0,0688	0,0001	0,0020	1,6922	0,0005	0,0003	0,0354	0,0017	0,0038	0,0003	31,3507
41-17	0,0665	0,0003	0,0022	1,6719	0,0005	0,0008	0,0502	0,0013	0,0113	0,0011	13,6771
42-17	0,0268	0,0001	0,0013	0,7021	0,0003	0,0004	0,0219	0,0009	0,0055	0,0006	11,0725
43-17	0,0697	0,0001	0,0014	0,9278	0,0006	0,0003	0,0231	0,0012	0,0033	0,0005	20,9866
44-17	0,0735	0,0003	0,0021	2,1028	0,0006	0,0007	0,0499	0,0071	0,0082	0,0010	20,5116
45-17	0,0453	0,0001	0,0009	0,2713	0,0005	0,0001	0,0093	0,0023	0,0022	0,0001	28,1458
46-17	0,0464	0,0001	0,0004	0,1789	0,0006	0,0001	0,0062	0,0011	0,0009	0,0001	27,7350
47-17	0,0666	0,0001	0,0004	0,3940	0,0012	0,0002	0,0061	0,0012	0,0007	0,0003	41,2821
48-17	0,0943	0,0003	0,0018	1,8254	0,0011	0,0103	0,0323	0,0142	0,0116	0,0006	32,6404
49-17	0,0947	0,0003	0,0029	2,0237	0,0013	0,0011	0,0418	0,0028	0,0090	0,0014	22,2550
50-17	0,1216	0,0005	0,0065	2,0686	0,0023	0,0046	0,0518	0,0025	0,0123	0,0013	37,2653
51-17	0,0891	0,0003	0,0055	1,7230	0,0012	0,0037	0,0433	0,0020	0,0090	0,0008	20,9129
52-17	0,0540	0,0002	0,0025	6,9026	0,0010	0,0007	0,0406	0,0060	0,0100	0,0005	19,3932
53-17	0,0577	0,0001	0,0009	0,5420	0,0009	0,0003	0,0160	0,0019	0,0019	0,0002	27,5293
54-17	0,0614	0,0001	0,0006	0,4218	0,0017	0,0002	0,0115	0,0016	0,0024	0,0002	31,6395
55-17	0,0612	0,0001	0,0009	0,5636	0,0021	0,0003	0,0176	0,0018	0,0029	0,0003	28,8037
56-17	0,0349	0,0001	0,0011	0,5505	0,0008	0,0005	0,0190	0,0028	0,0022	0,0002	14,7445
57-17	0,0534	0,0002	0,0016	1,2651	0,0012	0,0006	0,0320	0,0016	0,0064	0,0008	15,2209
58-17	0,0556	0,0002	0,0016	1,1792	0,0015	0,0005	0,0332	0,0019	0,0042	0,0004	20,7368

id	Sr	Tb	Th	Ti	Tl	U	V	W	Y	Yb	Zn
59-17	0,0410	0,0001	0,0008	0,7031	0,0005	0,0003	0,0187	0,0032	0,0025	0,0003	19,6688
60-17	0,0411	0,0001	0,0004	0,3439	0,0004	0,0001	0,0117	0,0021	0,0013	0,0002	19,7144
61-17	0,0506	0,0001	0,0013	0,7866	0,0014	0,0004	0,0222	0,0011	0,0022	0,0003	20,9431
62-17	0,0551	0,0001	0,0012	1,7006	0,0013	0,0004	0,0157	0,0007	0,0022	0,0004	23,0381
63-17	0,1333	0,0003	0,0020	3,7530	0,0015	0,0008	0,1267	0,0035	0,0108	0,0010	24,9154
64-17	0,1110	0,0001	0,0011	0,6500	0,0015	0,0005	0,0200	0,0015	0,0020	0,0002	27,0324
65-17	0,0832	0,0001	0,0004	0,3308	0,0018	0,0002	0,0069	0,0012	0,0018	0,0002	27,1461
66-17	0,0638	0,0001	0,0004	0,2195	0,0025	0,0001	0,0051	0,0011	0,0009	0,0002	26,3914
67-17	0,0632	0,0001	0,0005	0,4845	0,0011	0,0004	0,0108	0,0025	0,0026	0,0003	23,2550
68-17	0,0885	0,0002	0,0012	0,5655	0,0014	0,0005	0,0131	0,0012	0,0037	0,0003	30,4894
69-17	0,1490	0,0001	0,0007	0,4514	0,0023	0,0004	0,0131	0,0101	0,0021	0,0002	27,2349
70-17	0,0822	0,0001	0,0002	0,2290	0,0021	0,0002	0,0045	0,0009	0,0008	0,0002	27,8161
71-17	0,0896	0,0001	0,0006	0,5837	0,0022	0,0003	0,0116	0,0017	0,0022	0,0002	27,0023
1-18	0,0190	0,0000	0,0004	0,3069	0,0001	0,0003	0,0099	0,0027	0,0010	0,0001	5,3931
2-18	0,0310	0,0002	0,0012	1,7161	0,0002	0,0003	0,0234	0,0032	0,0029	0,0009	11,1858
3-18	0,0416	0,0001	0,0005	1,5511	0,0003	0,0009	0,0237	0,0057	0,0027	0,0003	11,1638
4-18	0,0202	0,0001	0,0003	1,0758	0,0001	0,0005	0,0151	0,0028	0,0017	0,0002	3,6967
5-18	0,0297	0,0001	0,0001	0,4507	0,0002	0,0009	0,0150	0,0025	0,0021	0,0004	7,4252
6-18	0,0942	0,0005	0,0022	2,8514	0,0005	0,0026	0,0836	0,0165	0,0108	0,0014	11,8016
7-18	0,0753	0,0003	0,0014	1,7583	0,0004	0,0010	0,0676	0,0138	0,0077	0,0007	6,9847
8-18	0,0303	0,0001	0,0009	0,5581	0,0002	0,0007	0,0245	0,0054	0,0032	0,0003	7,4062
9-18	0,0573	0,0003	0,0024	2,2380	0,0003	0,0011	0,0498	0,5155	0,0123	0,0010	8,2430
10-18	0,0330	0,0003	0,0023	1,0644	0,0006	0,0014	0,0319	0,0060	0,0090	0,0007	7,0885
11-18	0,0567	0,0002	0,0006	0,8281	0,0004	0,0008	0,0269	0,0035	0,0046	0,0004	7,6073
12-18	0,0657	0,0003	0,0013	1,3046	0,0003	0,0016	0,0505	0,0061	0,0070	0,0008	7,9211
13-18	0,0725	0,0002	0,0010	0,8269	0,0003	0,0013	0,0247	0,0042	0,0044	0,0007	7,8949
14-18	0,0443	0,0002	0,0014	1,5080	0,0003	0,0014	0,0381	0,0020	0,0044	0,0005	7,6542
15-18	0,0996	0,0005	0,0028	2,1836	0,0005	0,0019	0,0748	0,0038	0,0129	0,0012	9,1725
16-18	0,0624	0,0003	0,0025	1,6596	0,0002	0,0013	0,0450	0,0233	0,0080	0,0007	9,1808
17-18	0,0874	0,0005	0,0052	3,1836	0,0007	0,0043	0,1149	0,0112	0,0153	0,0018	7,1190
18-18	0,0733	0,0002	0,0020	1,5668	0,0005	0,0014	0,0414	0,0152	0,0054	0,0008	10,8389
19-18	0,0335	0,0001	0,0013	0,7043	0,0004	0,0006	0,0172	0,0042	0,0057	0,0007	7,1063
20-18	0,0772	0,0003	0,0026	1,3383	0,0003	0,0015	0,0360	0,0116	0,0063	0,0009	8,2138
21-18	0,0687	0,0003	0,0026	1,5263	0,0004	0,0015	0,0412	0,0090	0,0082	0,0009	11,0232
22-18	0,0442	0,0002	0,0017	1,2918	0,0004	0,0010	0,0369	0,0041	0,0059	0,0008	9,5928
23-18	0,0901	0,0003	0,0021	3,5390	0,0004	0,0013	0,1023	0,0072	0,0100	0,0011	8,6993
24-18	0,0805	0,0002	0,0017	1,4736	0,0007	0,0016	0,0488	0,0050	0,0074	0,0008	12,5420
25-18	0,0367	0,0001	0,0009	0,2524	0,0002	0,0003	0,0105	0,0025	0,0010	0,0002	13,1699
26-18	0,2522	0,0017	0,0143	8,8123	0,0019	0,0127	0,3097	0,0036	0,0468	0,0050	8,1508
27-18	0,0412	0,0001	0,0073	0,6216	0,0006	0,0002	0,0066	0,0025	0,0006	0,0003	14,1493
28-18	0,1117	0,0008	0,0297	0,6905	0,0020	0,0002	0,0321	0,0020	0,0013	0,0003	23,3735
29-18	0,0675	0,0001	0,0004	0,5816	0,0007	0,0005	0,0142	0,0034	0,0026	0,0006	25,9007
30-18	0,0354	0,0001	0,0052	3,3112	0,0005	0,0004	0,0140	0,0071	0,0019	0,0003	20,7928
31-18	0,0518	0,0000	0,0005	0,1333	0,0012	0,0001	0,0028	0,0007	0,0005	0,0001	20,6002
32-18	0,0406	0,0001	0,0016	0,7448	0,0005	0,0004	0,0249	0,0018	0,0057	0,0005	14,7727
33-18	0,0517	0,0002	0,0003	2,4754	0,0005	0,0003	0,0246	0,0015	0,0063	0,0011	16,4989
34-18	0,0540	0,0001	0,0006	0,6205	0,0007	0,0003	0,0180	0,0009	0,0025	0,0004	20,1084
35-18	0,0631	0,0001	0,0008	0,3429	0,0012	0,0001	0,0065	0,0015	0,0011	0,0001	18,8198
36-18	0,0265	0,0001	0,0012	1,0771	0,0003	0,0005	0,0277	0,0019	0,0031	0,0005	9,5263
37-18	0,0826	0,0002	0,0014	1,1156	0,0008	0,0008	0,0238	0,0141	0,0053	0,0005	22,5645
38-18	0,0783	0,0001	0,0012	0,8914	0,0002	0,0005	0,0202	0,0023	0,0034	0,0004	12,6702
39-18	0,1158	0,0000	0,0005	0,1185	0,0009	0,0002	0,0027	0,0003	0,0009	0,0001	30,1727
40-18	0,0768	0,0000	0,0002	0,4718	0,0007	0,0001	0,0067	0,0018	0,0009	0,0001	22,3512
41-18	0,0980	0,0005	0,0011	10,0039	0,0003	0,0009	0,2634	0,0029	0,0166	0,0019	8,4375
42-18	0,0275	0,0001	0,0006	0,2176	0,0002	0,0002	0,0058	0,0048	0,0007	0,0003	11,9220

Ingvild Buran Kroglund

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