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Author:	Director of the Office for Risk Assessment of the Food and Consumer Product Safety Authority
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OPINION OF THE DIRECTOR OF THE OFFICE FOR RISK ASSESSMENT AND RESEARCH FOR THE MINISTER OF AGRICULTURE, NATURE AND FOOD QUALITY AND THE MINISTER OF HEALTH, WELFARE AND SPORT

Advice on the food safety aspects of volcanic ash from Iceland

The Eyjafjallajökull volcano in Iceland erupted on 14 April 2010. During the following days, volcanic ash was carried towards the Netherlands on the wind.
The Office for Risk Assessment and Research (BuRO) of the Dutch Food and Consumer Product Safety Authority has investigated the potential consequences of the deposition of volcanic ash on agricultural crops (including produce grown for personal consumption) that are consumed by humans and animals. For its analysis, BuRO used data provided by the National Air Quality Monitoring Network of the National Institute for Public Health and the Environment (RIVM), a statement by the European Food Safety Authority and a report by the RIVM-RIKILT Front Office for Food Safety.

After studying the results of the last two weeks, BuRO concludes that the health risks to humans and animals from the consumption of agricultural crops that may have been contaminated by volcanic ash during this period are negligible.

BuRO recommends that the situation should be kept under review by means of the regular monitoring by the RIVM's National Air Quality Monitoring Network. Since data will soon be available at European level on the possible deposition of volcanic ash elsewhere in Europe, it would be advisable to reevaluate this advice if those data indicate that concentrations of harmful substances might still exceed levels regarded as safe for animals and humans.

In addition to particulate matter in the air, the RIVM's *National Air Quality Monitoring Network* measures chemical substances in the rain water (for example heavy metals and fluoride). There was very little precipitation in the Netherlands in the week after the eruption. Compared with the results of measurements performed prior to the eruption, no significant changes were found in the quantity of particulate matter in the air over the Netherlands or in the quantities of chemical substances in the rainfall in the week after the eruption.
At the request of the European Commission, the *European Food Safety Authority* (EFSA) issued a statement on 26 April. Since fluoride had been identified as the most critical compound related to health effects in earlier volcanic eruptions, the EFSA focused on the risk to humans and animals of consuming drinking water and/or crops that might be contaminated with fluoride. In its statement, the EFSA concluded that the potential health risk to humans and animals from additional exposure to fluoride was negligible in the European Union.

The *RIVM-RIKILT Front Office for Food Safety* opted to assess the risks from two perspectives. According to them, a lack of data made it impossible to estimate the exposure of Dutch consumers or grazing cattle to volcanic ash.
Since a substantial percentage of the food ingested by grazing cattle consists of grass and the soil attached to it, the Front Office compared the chemical composition of the volcanic ash, as determined in samples taken in Iceland, with the average levels of those chemicals in farm land in the Netherlands to assess the health risks for animals.

To assess the health risks for humans, the Front Office chose to determine, on the basis of certain assumptions, the maximum quantity of the volcanic ash that could be ingested without constituting a risk to public health.

The report of the RIVM-RIKILT Front Office for Food Safety showed that there was little difference in chemical composition between the samples of volcanic ash taken in Iceland and Dutch agricultural land (with the exception of fluoride). The comparison was made on the basis of seven similar metal oxides and 12 chemical elements. Although the concentrations of some substances are slightly higher in volcanic ash, they still fall within the margins of the background levels of chemical substances in the soil in the Netherlands. This comparison led to the conclusion that cattle in the Netherlands do not face a health risk from eating grass and earth that might have been contaminated with volcanic ash.

On the basis of a number of assumptions, the Front Office concluded that the consumption of volcanic ash by humans should be kept to a minimum (not more than the 'usual' ingestion of household dust and soil) in view of the presence of four critical substances (two metal oxides and two rare elements). However, BuRO feels that some of these assumptions are overly cautious and are unrealistic. It is highly unlikely that a quantity of volcanic ash sufficient to cause a health risk would be consumed on a daily basis and over a longer period.

No fruit crop is being harvested at the moment and only a few outdoor vegetables, such as leeks, some types of cabbage and spinach, are being grown or harvested. BuRO endorses the conclusion of the RIVM-RIKILT Front Office for Food Safety that it is not necessary to wash these vegetables more rigorously than usual.

Advies over voedselveiligheidsaspecten van vulkaanas uit IJsland

Op 14 april 2010 is de IJslandse vulkaan Eyjafjallajökull tot uitbarsting gekomen. In de daarop volgende dagen werd vulkaanas door de lucht meegevoerd richting Nederland.
Het bureau Risicobeoordeling en Onderzoeksprogrammering (BuRO) van de VWA is nagegaan wat de mogelijke consequenties zijn van de depositie van deze vulkaanas op landbouwgewassen (inclusief teelt voor eigen consumptie) die door mens of dier worden geconsumeerd. Het BuRO heeft hiervoor de gegevens gebruikt van het Landelijk Meetnet Luchtkwaliteit van het RIVM, een verklaring van de Europese Autoriteit voor Voedselveiligheid en een rapport van het RIVM-RIKILT Frontoffice Voedselveiligheid.

Na bestudering van de resultaten van de afgelopen twee weken concludeert het BuRO dat het gezondheidsrisico voor mens of dier van consumptie van landbouwgewassen, die in deze periode verontreinigd zouden kunnen zijn met vulkaanas, verwaarloosbaar is.

Het BuRO adviseert om door middel van de gebruikelijke monitoring van het Landelijk Meetnet Luchtkwaliteit van het RIVM de vinger aan de pols te houden. Aangezien op Europees niveau in de nabije toekomst gegevens beschikbaar zullen komen over de mogelijke depositie van vulkaanas elders in Europa lijkt het wenselijk om een herevaluatie van dit advies uit te voeren als deze gegevens uitwijzen dat gezondheidsnormen voor dier of mens mogelijk toch kunnen worden overschreden.

Het *Landelijk Meetnet Luchtkwaliteit* van het RIVM meet naast het fijnstof in de lucht ook chemische stoffen in het regenwater (onder andere zware metalen en fluoride). In de week na de vulkaanuitbarsting is zeer weinig neerslag gevallen in Nederland. Vergeleken met de resultaten van metingen uitgevoerd voorafgaand aan de vulkaanuitbarsting werden in de week van de uitbarsting geen wezenlijke veranderingen waargenomen in de hoeveelheid fijnstof in de lucht boven Nederland en in de hoeveelheid chemische stoffen die met regenwater op het land zijn gekomen.
Op verzoek van de Europese Commissie heeft de *Europese Autoriteit voor Voedselveiligheid* (EFSA) op 26 april een verklaring uitgebracht. Vanwege het feit dat bij eerdere vulkaanuitbarstingen fluoride de meest kritische verbinding bleek te zijn voor gezondheidseffecten, heeft EFSA zich vooral gebogen over het risico voor mens en dier door de consumptie van drinkwater en/of gewassen mogelijk verontreinigd met fluoride. EFSA concludeert in bovengenoemde verklaring dat het gezondheidsrisico veroorzaakt door een additionele blootstelling aan fluoride voor mens en dier in de Europese Unie verwaarloosbaar is.

Het *RIVM-RIKILT Frontoffice Voedselveiligheid* heeft gekozen voor een tweesporen aanpak van de risicobeoordeling. Vanwege ontbrekende gegevens is het volgens hen niet mogelijk om te bepalen aan hoeveel vulkaanas de Nederlandse consument of het grazend vee blootgesteld zou kunnen zijn.
Aangezien een aanzienlijk percentage van het rantsoen van grazend vee bestaat uit gras en aanhangend grond heeft het Frontoffice voor het beoordelen van het gezondheidsrisico voor het dier de chemische samenstelling van de vulkaanas, zoals bemonsterd in IJsland, vergeleken met de gemiddelde Nederlandse landbouwgrond.
Voor het beoordelen van het gezondheidsrisico voor de mens heeft het Frontoffice ervoor gekozen om, op basis van bepaalde aannames, te bepalen hoeveel van deze vulkaanas mensen maximaal zouden mogen innemen zonder dat het een risico vormt voor de volksgezondheid.

Uit het rapport van het RIVM-RIKILT Frontoffice Voedselveiligheid blijkt dat de chemische samenstelling van de vulkaanas bemonsterd in IJsland weinig verschilt met de samenstelling van de Nederlandse landbouwgrond (m.u.v. fluoride). De vergelijking is gemaakt op basis van 7 overeenkomstige metaaloxiden en 12 chemische elementen. Weliswaar zijn de concentraties van sommige stoffen in vulkaanas wat hoger maar ze zijn nog binnen de marges van de achtergrondgehaltes van chemische stoffen in Nederlandse bodem. Op basis van deze vergelijking wordt geconcludeerd dat het Nederlandse vee door het eten van gras en grond, mogelijk verontreinigd met vulkaanas, geen gezondheidsrisico loopt.

Op basis van een aantal aannames concludeert het Frontoffice dat voor de mens de consumptie van vulkaanas tot een minimum (niet meer dan de 'gebruikelijke' grondinname) beperkt moet blijven vanwege de aanwezigheid van vier kritische stoffen (twee metaaloxiden en twee zeldzame elementen). Het BuRO is echter van mening dat enkele van deze aannames te voorzichtig en niet realistisch zijn. Het is hoogst onwaarschijnlijk dat dagelijks, en over een langere periode, een dusdanige hoeveelheid vulkaanas geconsumeerd wordt waardoor een gezondheidsrisico zou kunnen optreden.

Momenteel is er geen fruitoogst en worden slechts enkele vollegrondsgroenten zoals prei, sommige koolsoorten en spinazie, verbouwd of geoogst. Het BuRO steunt de conclusie van het RIVM-RIKILT Frontoffice Voedselveiligheid dat het niet noodzakelijk is om deze groenten anders dan gebruikelijk te wassen.

Onderbouwing

AANLEIDING

Op 14 april 2010 is de IJslandse vulkaan Eyjafjallajökull tot uitbarsting gekomen. In de daarop volgende dagen werd vulkaanas door de lucht meegevoerd naar Nederland. Doordat het transport over grote afstand heeft plaatsgevonden zal vermoedelijk slechts een klein gedeelte van de totale uitstoot door wind en/of regen op Nederlandse bodem zijn neergeslagen.
Gewoonlijk bestaat een wolk van vulkaanas hoofdzakelijk uit zeer fijne deeltjes die mineralen kunnen bevatten (o.a. metaaloxiden, fluoride, sulfaat en andere chemische elementen). Deze chemische stoffen kunnen door inademing in de longen van mens en dier terecht komen maar kunnen ook als stof neerdalen (droge depositie) of met het regenwater neerslaan (natte depositie) op Nederlandse bodem en gewassen.
Het bureau Risicobeoordeling en Onderzoeksprogrammering (BuRO) van de VWA heeft geprobeerd zich een beeld te vormen van de mogelijke consequenties van de depositie van deze chemische stoffen op landbouwgewassen (inclusief teelt voor eigen consumptie) die door mens of dier worden geconsumeerd.

VRAAGSTELLING EN AFBAKENING

Het BuRO heeft het RIVM-RIKILT Frontoffice Voedselveiligheid gevraagd om een beoordeling uit te voeren van de mogelijke risico's voor de gezondheid van mens en dier indien door hen landbouwgewassen worden gegeten die verontreinigd zijn met vulkaanas uit IJsland.
Hiervoor heeft het BuRO de volgende vragen gesteld:

1. Welke schadelijke stoffen kunnen in de IJslandse vulkaanas voorkomen die van betekenis kunnen zijn voor de veiligheid van het voedsel voor dier en/of mens?
2. Is het mogelijk dat door de depositie van deze vulkaanas momenteel (of op korte termijn) de concentraties aan schadelijke stoffen op landbouwgewassen significant toenemen ten opzichte van de achtergrondbelasting in Nederland?
3. Worden er momenteel metingen uitgevoerd in Nederland die iets kunnen zeggen over de concentraties van schadelijke stoffen in lucht en (regen)water? Zo ja, wanneer zijn dan de eerste resultaten te verwachten?
4. Is het nodig om vollegrondsgroente en/of fruit dat momenteel en in de nabije toekomst wordt geoogst, uit voorzorg (misschien beter dan gewoonlijk) te wassen of op een andere manier geschikt te maken voor consumptie? Zo ja, welk advies geldt dan voor welke groenten of welk fruit?

Het beoordelen van het mogelijke gezondheidsrisico voor mens (en/of dier) gerelateerd aan het inademen van vulkaanas (in de vorm van fijnstof) behoort niet tot het werkterrein van de Voedsel en Waren Autoriteit en is derhalve ook niet in dit advies meegenomen.

Aanpak
Een onderzoeksinstituut in IJsland heeft op 26 april 2010 de resultaten van een chemische analyse van de vulkaanas gepubliceerd (1). Aangezien er in die periode geen waarneembare droge of natte depositie van vulkaanas in Nederland was, werd de rapportage van dit instituut gebruikt als input voor de risicobeoordeling.

Door contacten met het RIVM bleek dat het Landelijk Meetnet Luchtkwaliteit (LML) van het RIVM in Nederland continue metingen uitvoert naar fijnstof in de lucht en naar chemische stoffen in regenwater. Het BuRO heeft vervolgens rechtstreeks contact gezocht met het LML en is door hen voorzien van de relevante meetgegevens.

Op 20 april 2010 heeft de Europese Autoriteit voor Voedselveiligheid (EFSA) het verzoek gekregen van de Europese Commissie om een risicobeoordeling uit te voeren naar de gezondheidsrisico's voor mens en dier indien deze blootgesteld zouden worden aan vulkaanas via de consumptie van voedsel. Aangezien medewerkers van het BuRO en EFSA op de hoogte waren van elkaars activiteiten is besloten samen te werken op dit terrein. Vanwege een korte opleveringstermijn, het gebrek aan gedetailleerde gegevens over de asneerslag in Europa, en het feit dat bij eerdere vulkaanuitbarstingen fluoride de meest kritische verbinding bleek te zijn voor gezondheidseffecten, heeft EFSA zich toegespitst op het risico voor mens en dier van de consumptie van drinkwater en/of gewassen verontreinigd met fluoride. Aangezien het RIVM-RIKILT Frontoffice Voedselveiligheid gekozen had voor een andere aanpak van de risicobeoordeling (zie volgende alinea) is besloten om onnodige duplicatie van de specifieke risicobeoordeling van EFSA te vermijden.

Het Frontoffice heeft gekozen voor een tweesporen aanpak van de risicobeoordeling. Vanwege ontbrekende gegevens is het volgens hen niet mogelijk om te bepalen aan hoeveel vulkaanas de Nederlandse consument of het grazend vee blootgesteld zouden kunnen zijn of worden. Voor het beantwoorden van de vraag of de concentraties aan schadelijke stoffen in landbouwgewassen toenemen, is een vergelijking gemaakt van de chemische samenstelling van de vulkaanas, zoals in IJsland bemonsterd, en de gemiddelde Nederlandse landbouwgrond. Aangezien een aanzienlijk percentage van het rantsoen van grazend vee bestaat uit gras en aanhangend grond, kan de inname van grond (en gras) verontreinigd met vulkaanas een bijdrage leveren aan het risico voor de diergezondheid.
Voor het beoordelen van het gezondheidsrisico voor de mens heeft het RIVM-RIKILT ervoor gekozen om, op basis van bepaalde aannames, te bepalen hoeveel van deze vulkaanas mensen maximaal zouden mogen innemen zonder dat het een risico vormt voor de volksgezondheid.

UITGANGSPUNTEN

Samenstelling van de vulkaanas
Het is onbekend of door het transport over lange afstand de samenstelling van de vulkaanas verandert. Het vermoeden bestaat dat met name het zogenaamde fijnstof (stof met deeltjes kleiner dan 10 micrometer) over grote afstand wordt getransporteerd. Omdat bij het uitgaan van dit advies nog geen metingen zijn uitgevoerd naar vulkaanas neergeslagen op Nederlandse bodem hebben de onderzoekers aangenomen dat de vulkaanas die mogelijk in Nederland is neergeslagen dezelfde samenstelling heeft als de vulkaanas zoals bemonsterd in IJsland.

Biologische beschikbaarheid
In de risicobeoordeling uitgevoerd door het RIVM-RIKILT is de biologische beschikbaarheid van alle chemische stoffen, m.u.v. siliciumoxide en titaanoxide, aanwezig in de vulkaanas gesteld op 100%. Dat wil zeggen dat is aangenomen dat de overige 21 mineralen, al dan niet in gebonden vorm, volledig vrijkomen uit de vulkaanas en volledig worden geabsorbeerd door het menselijk lichaam. Deze aanname zal in veel, zo niet alle, gevallen leiden tot een overschatting van het risico en is derhalve een worst-case scenario.

Toxicologische referentiewaarden
Voor een aantal (zeldzame) elementen als scandium, yttrium en zirkonium zijn geen internationaal erkende gezondheidsnormen bekend. RIVM-RIKILT heeft voor deze stoffen voorlopige toelaatbare dagelijkse innames berekend die nog niet door collega-deskundigen in de internationale context zijn getoetst.

BEVINDINGEN

Samenstelling vulkaanas
Op 26 april 2010 heeft een onderzoeksinstituut in IJsland (Institute of Earth Sciences van de universiteit van IJsland) de eerste resultaten gepubliceerd van chemische analyses uitgevoerd op vijf verschillende monsters vulkaanas (1). Dit overzicht toont aan dat verreweg het grootste deel van de vulkaanas (99,7%) bestaat uit metaaloxiden. Daarnaast zijn er nog enkele elementen aangetoond die slechts 0,2% uitmaken van de vulkaanas. Van de metaaloxiden bestaat het grootste deel uit siliciumoxide (57,7%), aluminiumoxide (15,5%) en ijzeroxide (9,6%).
De gemeten gehaltes aan chemische stoffen zijn gebruikt voor de beoordeling van het risico voor mens en dier door het RIVM-RIKILT.

Fijnstof en regenwater
Het Landelijk Meetnet Luchtkwaliteit (LML) van het RIVM meet continue de hoeveelheid fijnstof in Nederland. Uit mondelinge rapportage van het LML blijkt dat er geen wezenlijke veranderingen zijn waargenomen in de hoeveelheid fijnstof in de lucht. In de dagen na de vulkaanuitbarsting is weinig neerslag gevallen in Nederland (minder dan 1,5 mm) en slechts op 3 noordelijke meetlocaties konden monsters worden genomen waarin onder andere fluoride, sulfaat en zware metalen zijn bepaald. De hoeveelheid fluoride en sulfaat is hoger dan de week voorafgaand aan de vulkaanuitbarsting maar niet afwijkend tov. de periode 2006-2009 (2).
Uit het bovenstaande wordt geconcludeerd dat er tot op heden zeer weinig droge en natte depositie van vulkaanas in Nederland heeft plaatsgevonden.

Risicobeoordeling fluoride
Uit een factsheet van het Productschap Diervoeder blijkt dat, onder normale omstandigheden, het gehalte aan fluoride in Nederlandse grond afhankelijk is van de grondsoort en varieert van 60 mg/kg droge stof in veengrond tot 450 mg/kg droge stof in rivierklei (3). Daarmee is het hoogste gehalte aan fluoride in Nederlandse grond ongeveer de helft van het hoogste gehalte aan fluoride gemeten in het IJslandse vulkaanas.

Vanwege het feit dat bij eerdere vulkaanuitbarstingen fluoride de meest kritische verbinding bleek te zijn voor gezondheidseffecten en het gehalte aan fluoride in de vulkaanas was toegenomen (van 23-35 mg/kg op 14 april naar 850 mg/kg op 19 april 2010) heeft EFSA zich vooral gebogen over het risico voor mens en dier van de consumptie van drinkwater en/of gewassen verontreinigd met fluoride (4). Voor de mens is verontreinigd drinkwater de belangrijkste route van blootstelling aan fluoride en voor grazend vee is dat de directe inname van vulkaanas neergeslagen op gras en grond.
EFSA concludeert op basis van de huidige informatie dat het mogelijke risico veroorzaakt door een additionele blootstelling aan fluoride voor mens en dier in heel Europa verwaarloosbaar is. Ondanks een andere aanpak in de berekening van het mogelijke risico komt het RIVM-RIKILT Frontoffice Voedselveiligheid tot dezelfde conclusie (5).

Risicobeoordeling mineralen
Zoals besproken onder de paragraaf aanpak heeft het RIVM-RIKILT Frontoffice Voedselveiligheid met name twee onderwerpen onderzocht: een vergelijking van de chemische samenstelling van de IJslandse vulkaanas met de Nederlandse bodem en een berekening van de hoeveelheid vulkaanas

die mensen maximaal mogen innemen zonder dat het een risico vormt voor de volksgezondheid (5).

Een vergelijking van achtergrondgehaltes van metaaloxiden en elementen in de Nederlandse bodem met gehaltes van deze chemische stoffen in vulkaanas geeft aan dat er weinig verschil is in chemische samenstelling en gehaltes. Door dit geringe verschil én de geringe depositie van de vulkaanas tot op heden wordt geconcludeerd dat het additionele gezondheidsrisico voor grazend vee door inname van gras en grond (mogelijk) verontreinigd met vulkaanas verwaarloosbaar is.

Voor elk van de in totaal 21 onderzochte chemische stoffen (aanwezig in de vulkaanas bemonsterd in IJsland) is op basis van de toxiciteit uitgerekend hoeveel vulkaanas mensen maximaal mogen innemen zonder dat deze 'theoretische' inname een risico vormt voor de volksgezondheid (5).
Voor 17 chemische stoffen is de hoeveelheid vulkaanas die mensen dagelijks mogen innemen zonder dat het een risico vormt voor de gezondheid (veel) meer dan 1 gram per persoon.
Door de combinatie van een aantal conservatieve aannames in de berekeningen van het Frontoffice RIVM-RIKILT geldt voor 4 stoffen (aluminiumoxide, ijzeroxide, yttrium en zirkonium) dat de maximaal ingenomen hoeveelheid vulkaanas minder dan 1 gram moet zijn. Naar de mening van het BuRO zorgt de combinatie van de conservatieve aannames (100% biologische beschikbaarheid voor deze vier stoffen en conservatieve gezondheidsnormen voor yttrium en zirkonium) ervoor dat de schattingen voor de maximaal in te nemen hoeveelheid vulkaanas te voorzichtig en niet realistisch zijn.
Bovendien zijn de hoeveelheden aluminiumoxide, ijzeroxide, yttrium en zirkonium in de vulkaanas vergelijkbaar met de hoeveelheden in de Nederlandse bodem.

CONCLUSIES

Fijnstof en regenwater

Vergeleken met de resultaten van metingen uitgevoerd in Nederland voorafgaand aan de vulkaanuitbarsting werden de afgelopen week geen wezenlijke veranderingen waargenomen in de hoeveelheid fijnstof in de lucht en in de hoeveelheid chemische stoffen die met regenwater op het land zijn gekomen. Gelet op de geringe (natte en droge) depositie van de vulkaanas tot op heden is het niet waarschijnlijk dat dieren of mensen schadelijke hoeveelheden vulkaanas via het voedsel hebben ingenomen.

Beoordeling van het risico voor diergezondheid

Een vergelijking van achtergrondgehaltes van metaaloxiden en elementen aanwezig in de Nederlandse bodem met gehaltes van deze chemische stoffen in vulkaanas geeft aan dat er weinig verschil is in chemische samenstelling en in gehaltes aan stoffen. Door dit geringe verschil én de geringe depositie van de vulkaanas tot op heden wordt geconcludeerd dat het gezondheidsrisico voor grazend vee door inname van grond en gras verontreinigd met vulkaanas verwaarloosbaar is.

Beoordeling van het risico voor volksgezondheid

Gelet op de geringe depositie van de vulkaanas tot op heden is het niet waarschijnlijk dat mensen door de consumptie van vollegrondsgroente hoeveelheden vulkaanas kunnen innemen die schadelijk zouden kunnen zijn voor hun gezondheid. Bovendien zal het wassen van deze groenten bijdragen aan een verdere verlaging van het reeds verwaarloosbare risico.

Hoogachtend,

Prof. dr. E.G. Schouten
Directeur bureau Risicobeoordeling en Onderzoeksprogrammering

Bijlagen:

- Briefrapport Centrum Inspectie- Milieu en Gezondheidsadvisering van het RIVM. Resultaten analyse regenwater, d.d. 28 april 2010

- RIVM-RIKILT Front Office Food Safety. Risk assessment concerning the potential exposure via food and feed to ashes from the Eyjafjalojökull volcano, d.d. 29 April 2010

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Bijlagen

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2. RIVM-RIKILT Front Office Food Safety. Risk assessment concerning the potential exposure via food and feed to ashes from the Eyjafjallajökull volcano in the Netherlands, d.d. 29 april 2010

RIVM-RIKILT FRONT OFFICE FOOD SAFETY

RISK ASSESSMENT CONCERNING THE POTENTIAL EXPOSURE VIA FOOD AND FEED TO ASHES FROM THE EYJAFJALLAJÖKULL VOLCANO IN THE NETHERLANDS

Risk assessment requested by:	Dr. Marcel Mengelers (Dutch Food and Consumer Products Safety Authority, Office for Risk Assessment)
Risk assessment performed by:	*RIVM and RIKILT*
Date of request:	20-04-2010
Date of risk assessment:	29-04-2010 *(final)*
Co-ordinator:	Dr. W. Mennes
Author(s) risk assessment:	Dr. W. Mennes (RIVM), Dr. R. Hoogenboom (RIKILT)
Reviewer(s) risk assessment:	Dr. C. de Heer, Ir. P. Bos *(RIVM)*
Project number:	V/320110/10/FA and V/320800/10/AA

Subject

During April 2010 large parts of the European atmosphere became polluted with volcanic ashes of the Eyjafjallajökull volcano on Iceland. It may be anticipated that because transport of ashes takes place over large distances, a small part of the ashes will deposit on Dutch territory. The Dutch Food and Consumer Products Safety Authority tries to appreciate the consequences for human and animal health of potential depositions of ash on food and feed crops (including home-grown crops). The RIVM-RIKILT Front Office Food Safety was asked to provide an advice addressing the following questions regarding food and feed safety:

Questions

1. Which dangerous substances may occur in these volcanic ashes which may affect the safety of food and feed?
2. Is it possible that as a result of deposition, concentrations of harmful substances in crops can increase significantly, already now or in near future, in comparison with background levels in the Netherlands?
3. Is chemical analysis going on which may provide information on the concentrations of harmful substances in air and (rain)water. If so, when can results be expected?
4. Is it necessary to precautionary wash or treat fruit and open-air vegetables (more rigorously than usual) in order to make them suitable for consumption? If so, which advice would be applicable to which vegetables and which fruits?

Conclusion

1) Analytical results provided by the Institute of Earth Sciences; University of Iceland have shown that the ashes in the proximity of the volcano consist mainly of silicon-oxide and aluminum-oxide. Several other minerals (oxides) were found in relatively high amounts (calcium, manganese, magnesium, iron, sodium, potassium, titanium and phosphorous. Together these comprised 99.7% of the analysed material (range: ~ 2.7 – 577 g/kg). Other elements which have been identified are Ba, Co, Cr, Cu, Ni, Sc, Sr, V, Y, Zn and Zr which comprised 0.16% of the analysed material (range; ~ 16 – 460 mg/kg). No data were provided as to the chemical speciation of these elements. In addition to these, also 23-35 mg of soluble fluoride/kg was found. Based on the composition of the volcano ashes, it can be concluded that ingestion of 100 mg of ash per day would not result in damage to health, for any of the elements found. This is a lower bound estimate based on worst case assumptions with respect to release and bioavailability of the elements from the ash matrix. The 100 mg lower bond estimate is driven by the high level of aluminum-oxide in the volcano ashes. However, the amount of aluminum in the ashes is not significantly higher than in Dutch soil for which no risks are known. Other elements which would put a significant limit to the maximum amount of ash that can be safely ingested (100 – 400 mg/d) are Scandium (Sc), Yttrium (Y) and Zirconium (Zr), but the assessment procedure for these elements probably overestimates the risk. No specifically low maximum intake of ashes was identified to prevent excessive exposure to fluorine.
   Foraging animals may ingest a large amount of soil. However, based on the comparison of the reported composition of the Icelandic volcanic ash with the composition of Dutch soil, no significant change in Dutch soil composition is expected as a result of the deposition of this ash. Consequently no health risk or risk for significantly altered transfer of ash components into animal tissues is anticipated.
2) There are no indications that significant deposition of these ashes onto edible crops or feed has occurred. Limited data available, based on rainwater sample analyses, indicate that the amount of minerals deposited onto Dutch soils is negligible in comparison to the background concentrations of these minerals.
3) Rainwater samples collected in the Netherlands have been analysed. In addition dust collected from airliner surfaces has been studied. The first results of the investigation of rain samples indicate that concentrations of a few elements in rain were slightly higher than in rain samples from the period before the eruption (2006-2009). However, the concentrations were well-within the normal ranges. It may be concluded that some minimal deposition from this rain fall has occurred. The ash samples collected from airliners showed no presence of fibrous material.
4) At this moment, in the Netherlands there are only few vegetables grown outdoors. These are late winter vegetables such as leeks or kale, and early spring vegetables such as spinach. There are no harvestable fruits. In later spring, fruits (e.g. strawberries, raspberries, red currants) will be harvested and also the number of outdoor-grown vegetables will increase (e.g. lettuce, endive). As deposition of ashes is currently hardly detectable, there is no need to wash fruits or vegetables more rigorously than normal.

Introduction

The volcano Eyjafjallajökull has sent into the atmosphere a huge amount of minerals in the form of particulate matter (ash), 25% of which consisted of particles falling into the PM10 category (http://www.earthice.hi.is/page/ies_Eyjafjallajokull_eruption; access date April 26, 2010). Because the larger particles will fall out closest to the volcano, it can be anticipated that the fraction of PM10 in the Ash cloud over the European continent will be considerably higher.

Limited data have become available up to now with respect to the analytical composition of the volcanic ashes in the proximity of the volcano. It may be anticipated that the composition of the atmospheric ashes over the Netherlands may deviate from this, but in a first approach the following information as provided by the Institute of Earth Sciences; University of Iceland could be considered (http://www.earthice.hi.is/page/IES-EY-CEMCOM; access date April 26, 2010):

Table 1: Average composition of 5 ash samples collected near the Eyjafjallajökull volcano, April 14th, 2010

A: Major components:		
	contents	
	oxide	**element**
oxide	**g/kg ash**	**g/kg ash**
SiO_2	576.8	269.2
Al_2O_3	154.8	82.0
FeO	96.2	74.8
MnO	2.7	2.1
MgO	21.6	13.0
CaO	51.6	36.9
Na_2O	52.8	39.2
K_2O	17.0	14.1
TiO_2	16.0	9.6
P_2O_5	7.5	3.3
Summed percentage of bulk:	99.7%	
B: minor components:		
	contents	
element	**mg/kg ash**	
Ba	418.6	
Co	27.8	
Ni	18.0	
Sc	16.4	
Sr	356.4	
V	59.2	
Y	82.6	
Zr	463.8	
F	26.6	
Cu	25.2	
Zn	126.4	
Cr	34.0	
Summed percentage of bulk:	0.16%	

Reported levels of soluble fluoride in the ash ranges from 23-35 mg/kg of ash in samples collected on the 14th of April. The concentration of fluoride in the volcanic ashes has increased up to a level of 850 mg/kg of ash in samples collected more recently (19-04-2010). This increase may be related to the fact that less steam is produced resulting in a reduced wash-off effect (http://www.earthice.hi.is/page/ies_Eyjafjallajokull_eruption; access date April 26, 2010).

EFSA (2010) issued a statement (urgent advise) on the possible risks for public and animal health from the contamination of the food and feed chain due to possible ash-fall. Focus lies initially on possible risks from fluoride in the volcanic ash as this chemical was identified in previous volcano eruption risk assessments as most critical compound related to health effects in both humans and animals. As further EU monitoring data becomes available for volcanic ash deposition levels and ash composition, risks associated with the components of the volcanic ash fall should be re-evaluated, if the data indicates that toxicological thresholds have been exceeded.
EFSA concluded that contamination of drinking water, vegetables, fruit, fish, milk, meat and feed with fluoride is regarded as negligible in the EU which is outside the immediate proximity of the

Eyjafjallajökull volcano. Consequently, the risk for human and animal health due to this ash-fall is considered not to be of concern.

Toxicology

For the components which have been included in the analysis (see table 1) reference values for chronic or sub-chronic exposure have been collected from literature (See Annex I). These values were collected from RIVM reports or from other international evaluating organisations, such as ATSDR (USA), or EFSA. For Sc, Y and Zr, no values could be found from other organisations. No comprehensive description of the various ash components, which are considered in this report have been included. For details on the toxicological properties of the ash components, the reader is referred to the various source documents.

In 1994, RIVM has derived preliminary TDIs of 0.5 μg/kg bw/d for Sc and Y from long-term studies in mice given these two elements at a single dose level of approximately 0.5 mg/kg bw/d via the drinking water (Schroeder and Mitchener, 1971). Since slight effects were observed at this dose level, an assessment factor of 1000 was used to derive the preliminary TDI. Also for Zr, a life-time single dose study in mice was identified (Schroeder *et al.,* 1968) in which a dose of 0.5 mg/kg bw/d was identified as an effect level. Based on this observation a tentative TDI of 0.5 μg/kg bw/d could be derived in the same way as has been done for Sc and Y.

For some of the chemical elements considered no toxicological reference values were found, but some sources have indicated levels of exposure which were not associated with toxicity, based on human data. In these cases the exposure levels mentioned have been used in this report as “safe level” or “target value” (see ANNEX I). It is noted that levels at which toxicity could occur will be higher. Therefore, the use of these “safe levels” can be considered conservative.

Exposure

The data generated by the Dutch National Air Quality Monitoring Network have not shown consistently increased air concentrations of fine particulate matter (PM10) outside the normal range and typical amounts of 10 - 30 μg/m^3 have been observed over the last days. Incidentally higher values up to 75 μg/m^3 have been observed, in particular in the south-eastern part of the country. These levels were only of short duration, and no indications have been obtained that these higher values were related to the presence of volcanic ashes or that significant amounts of ashes have deposited on Dutch soil or surfaces, including crops.

Samples from dust collected from airliners were studied by the National Aerospace Laboratory (NLR). No effect on Dutch soil composition is to be expected. The dust samples from airliners were studied by electroscopy. The shape of the particles is in line with what can be expected for dust. Fibrous particles were not observed.

A limited number of rain water samples (in the north of the Netherlands) has been analysed by RIVM. The results from the rain water samples indicate a slightly higher deposition of S and F on Dutch soils after the eruption, compared to the same amount of rainfall the years before (2006-2009). However, these concentrations fall well within in the normal range.

It is further noted that given the time of the year, at the moment only late winter vegetables (leeks, kale) or early spring vegetables (spinach) are grown outdoors. Later in spring also lettuce, endives and other vegetables may be harvested. Early outdoor fruits are strawberries. Later in spring / early summer, also other fruits such as cherries, raspberries and red currants could come into contact with ash deposits.

Risk assessment

Risk assessment for humans

Since no data are available at this moment to estimate exposure to ashes via vegetables, soil or drinking water, a different approach has been taken to get an impression of the possibility of health effects resulting from the possibly deposited material on vegetables. First, the maximum ash ingestion calculated to be without concern for the individual compounds was determined. Second, to put these calculations into perspective, the results were compared to data on the ingestion of 'normal' house dust and soil. It should be noted that the 'behaviour' of volcano ash, due to its specific composition, may be different from house dust.

The conservative but realistically estimated amount of 'normal' house dust ingested is 100 mg/d for a child and 50 mg/d for an adult, which figures are used as defaults in exposure estimations by RIVM, based on an extensive literature search. The 95th percentile is 200 mg/d (Oomen et al, 2008)[1]. Also for soil ingestion, default estimates for risk assessment have been derived. These are 50 mg/d for an adult and 100 mg/d for a child[2] (Lijzen, 2001).

Based on the reported concentrations in Table 1 and health-based reference values for chronic or intermediate duration exposure (ANNEX I), estimates have been made of the maximum amount of ashes that would be anticipated not to result in health problems for the individual components in the ash samples. For this purpose, it is initially assumed that the materials analysed are 100% bioavailable: i.e. they will be completely released form the matrix and be fully absorbed. This may be considered an over-estimation as for many metals it is known that they are only absorbed to a limited extent, depending on the matrix in which they occur and on the presence of other ions (Nordberg, 2007). In principle this also relates to the materials used in toxicological studies but these were often selected for their relatively good bioavailability.

However, the assumption of "full availability" is not suitable as an initial assumption for silicium oxide, which is so insoluble in water that hardly any absorption may be anticipated. The same is applicable for titanium oxide and for both substances an ADI "not specified" has been derived (SCF, 1990; EFSA, 2004). Therefore, silicon-oxide and titanium oxide will not further be considered in this evaluation. There is no Upper level for sodium. However, the Health Council of the Netherlands (2006) indicated an upper target value of 6 g per day for intake of sodium chloride, which is equivalent to approximately 2.4 g of sodium per day, which value will be used to evaluate the possible exposure to sodium.

For aluminum and manganese a Tolerable weekly intake (TWI) and an Upper intake Level of 1 mg/kg bw/w and 11 mg per person per day have been derived by EFSA (2008) and U.S. Food and Nutrition Board/Institute of Medicine (FNB/IOM 2001; as cited in ATSDR 2008a; b), respectively.

Table 2: Maximal amount of volcanic ash that can be ingested without raising a concern for damage to health, based on the toxicity of the components mentioned in table 1.

element	Maximum ash ingestion$^{\$}$ (g ash per person per day)
Ba	33.4
Co	25.2
Ni	77.8

1 For inhalation of dust figures of 0.8 and 2 mg/d were estimated for a child or an adult, based on an indoor air dust concentration of 100 μg/m^3, which is a high estimate of actual concentrations in indoor air. Given the difference with ingestion of dust, the inhalation component is not further considered.

2 Previously values of 50 and 100 mg/d for adults and children, respectively, were used. In 2001, these values have been updated.

element	Maximum ash ingestion$ (g ash per person per day)
Sc	2.1
Sr	117.8
V	11.8
Y	0.4
Zr	0.1
F	315.8
Cu	230.6
Zn	199.4
Cr(III)insoluble	10294.1
Cr(III)soluble or Cr (VI)	10.3
Al	0.1
Fe	0.7
Mn	5.3
Mg	19.3
Ca	67.8
Na	61
K	212.7
P	918.6

$ The maximum ash intakes for the series Al, Fe, Mn, Mg, Ca, Na, K and P were calculated for the free elements mentioned; not for the oxides, as also the reference values in Annex I refer to the free elements.

From table 2 it can be seen that for most of the components, the amounts of ash that can be ingested before a health concern would be raised is well above 10 g per person per day. Only for a few elements, 10 g or less would not be without a health concern. These are Sc (2.1 g), Y (0.4 g), Zr (0.1 g), Cr (10.3 g), Al (0.1 g) and Fe (0.7). Possible risks associated with the combined exposure to these elements have not been assessed, since there are only few elements for which 10 g or less would not be without concern and there is a lack of knowledge on this matter.

By comparison with the figure used to estimate exposure to indoor dust (100 mg/d for a child, see above), the maximum quantities that could be ingested could be exceeded for Al and Zr. This may be appreciated even more when it is realised that with a fairly high density of 4 g/cm^3 for volcanic ash[3] (Iceland University) an amount of 0.1 g would have a volume as little as 25 μl, equivalent to a small drop of water. However, based on the preliminary nature of the TDI and the absence of any knowledge of speciation or bioavailability (based on the highly oxidised state of the major components, it could be anticipated that these metals would also be present as their respective oxides, with probably limited bioavailability) it is highly unlikely that a temporary limited ingestion of amounts of ash above 0.1 g would actually pose a real health risk. In addition, TDIs which have been used for Sc, Y and Zr are derived from two single-dose long-term studies in mice, with limited study parameters (Verweij *et al*, 1994; Schroeder *et al*, 1968). In order to cover uncertainty in this limited database, a relatively high assessment factor was used to calculate this preliminary TDI.

For Al the maximum quantity of ash that can be safely ingested would be 0.1 g/d and for this small amount, the same considerations with respect to volume would apply as for Sc, Y and Zr mentioned above. However, the TDI for Al is well-underpinned. For Al it was demonstrated that in the ashes, it occurs in the oxidised form (Al_2O_3). The oral bioavailability in humans of the aluminum ion from drinking water is around 0.3% whereas bioavailability from food and beverages generally is considered to be lower, about 0.1%. However, it has been argued that the oral absorption of aluminum from food can vary at least 10-fold depending on the chemical forms present in the intestinal tract (EFSA, 2008). Direct information on the availability of Al from Al_2O_3 is not available, but since this

[3] This is a very high estimate for the density, also when it is considered that ash deposits will be loosely packed with air included. Normally mineral fractions of soils in the Netherlands have a density of around 2.5 (Poelman, 1975). The value of 4 g/cm^3 mentioned in the text was used by the University of Iceland.

material is only slightly soluble in water or in diluted acids (EFSA, 2008), it may be anticipated that absorption of Al from the ashes will not be higher than anticipated from food. The Al contents in Dutch soils are approximately 8% (Van der Veer, 2006) for which there is no known risk. It is noted that the amount of Al in the ashes is not significantly different from Dutch soils, which in itself may indicate that risks determined by the procedure in the present evaluation., if any, are over-estimated.

The maximum quantity of ash which could be ingested with respect to the contents of Cr is highly dependent on the assumption of the form of Cr considered. If it is assumed that all chromium is in the soluble state, or in the hexavalent state, the maximum amount of ash for Cr would be ca. 10 g per day. However, the maximum amount for Cr is a factor 100 higher than the maximum amount considered safe for Al. If the latter intake is controlled than the intake of Cr will not give rise to concern.

The maximum amount of ash that could be ingested with respect to exposure to iron (Fe) is approximately 0.7 g/d, based on a TDI derived by JECFA in 1983. Although EFSA (2006) did not derive a TDI, from earlier JECFA evaluations the “provisional maximum TDI” for iron was taken for the present evaluation. Data provided by EFSA would not indicate that for a life-time intake of an amount of iron up to the JECFA TDI would result in dangers to health for the normal population, but people suffering from heamochromatisis may ultimately develop a serious health condition from prolonged intake of iron at this level. However, the JECFA-TDI for iron has been derived for soluble forms of iron, and as iron in the ashes is present as an oxide, the absorption will be considerably less that the 10 – 20% which is absorbed from soluble sources under conditions of iron deficiency (EFSA, 2006). According to JECFA (1983), iron in the form of FeO is not bioavailable. This means that the maximum ash ingestion with respect to iron is an overestimation of the risk and that ingestion of ash is unlikely to result in iron toxicity.

The initial Icelandic evaluation considered that due to high fluorine contents ingestion of ashes by farm livestock could lead to health damage in animals (http://www.earthice.hi.is/page/IES-EY-CEMCOM; access date April 26, 2010). However, for humans based on the initial fluorine contents of the Icelandic ash (23-25 mg/kg ash) ingestion of ash up to approximately 300 g (see table 2) would not be problematic. The later collected ash samples have as expected (http://www.earthice.hi.is/page/IES-EY-CEMCOM; access date April 26, 2010) a higher fluorine content (850 mg/kg of ash), and as a result, ingestion of such ashes should not be more than ca. 10 g. It is noted that these ash amounts are calculated for an adult. The upper tolerable level for fluorine in children (1-8 years old) is 0.1 mg/kg bw/d which corresponds to ingestions of 1.5 to 2.5 mg per child per day (EFSA, 2006) and this exposure to fluorine can be reached from ingestion of 2-3 g of ash (based on the fluorine content of 850 mg/kg ash).

Risk assessment for farm livestock

Animals foraging outside continuously ingest soil attached to grass, insects or worms. Therefore the most essential question is whether the volcanic ash contains elements that are normally not present in soil and may potentially affect the health of the animal. The Institute of Earth Sciences in Iceland (http://www.earthice.hi.is/page/ies_Eyjafjallajokull_eruption; access date April 26, 2010) investigated the ash derived from 5 different locations. Table 1 shows the levels observed. Not all trace elements were analysed. Therefore additional information was looked for at internet, revealing a paper from soil of the Azores (Amaral et al. 2006). In this study levels of trace elements in soil near active volcanic sites were in general lower than those from inactive sites. In some cases the levels of trace elements are somewhat higher than those reported for Iceland.

These data were compared with data of background soil samples in the Netherlands (Table 3) as described in the Regeling Bodemkwaliteit (2007) and described by Van der Veer (2006).

As can be seen from these data, there are no major differences between the levels of trace elements in the volcanic ash, the soil of the Azores or the Dutch background soil, at least not to an extent that levels in soil and possibly crops grown on these soils could show clearly elevated levels that could cause an increased exposure of animals.

Other elements like aluminum, iron, magnesium etc are normal constituents of soil. Aluminum e.g. makes up around 8% in soil. Correction of the observed level of Al_2O_3 for the content of aluminum results in a very similar level of 82 g/kg (8.2%) in the Icelandic volcanic ash. Iron makes up 5% of soil, as compared to 75 g/kg (7.5% of Fe) in the ash.

Table 3. Comparison of reported levels in volcanic ash with soil levels in the Netherlands

Mineral/Element	**Ash volcano (g/kg)**	**Soil Azores* (g/kg)**	**Background NL** (g/kg)**	**Background NL*** (g/kg)**
SiO_2	577			272-468
Al_2O_3	155			5-88
FeO	96			0-62
MnO	2.7			0-1.9
MgO	21.6			0-15.3
CaO	51.6			0-66
Na_2O	52.8			
K_2O	17.0			
TiO_2	16.0			0.3-6.2
P_2O_5	7.5			
	(mg/kg)	**(mg/kg)**	**(mg/kg)**	**(mg/kg)**
Ba	404-429		190	104-620
Cd		Nd-0.8	0.6	0.0-1.9
Cr	19-47	Nd-958	55	9-128
Co	26-31	2-111	15	
Cu	22-31	18-117	40	0-72
Hg			0.15	0.0-0.6
Pb		9-83	50	4-166
Mo			1.5	0.1-2.6
Ni	15-23	3-483	35	0-63
V	47-95		80	5-140
Y	82-83		5-17*	3.9-38.4
Zn	124-132	72-258	140	0-332
Zr	458-472		250*	35-662

* Amaral et al. (2006)

* * Regeling Bodemkwaliteit (2007)

*** from Van der Veer 2006, as free elements, Elevated levels of fluoride in volcanic ashes are a well-known cause of fluorosis in grazing animals. Cronin et al. (2000) using a model, suggested that at soil ingestion levels of 143-300 g/d by sheep and 900-1600 g/d for cattle, and a dietary F absorbtivity (bioavailability) of soil F (20-38%), total topsoil F concentrations in the range of 372-1461 mg F per kg could cause chronic fluorosis in sheep and 326-1085 mg F per kg soil in cattle. At the maximum observed levels of soluble F of 23-850 mg/kg and the very limited deposition, it seems very unlikely that grazing animals in the Netherlands may be exposed to such high levels. Furthermore it is noted that there will probably be no chronic increas in the levels of F.

Levels in animals living on volcanic soils

Reykdal and Thorlacius (2001) investigated levels of Cd, Hg, Fe, Cu, Mn and Zn in livers and kidneys of lambs raised at different locations on Iceland, both near and further away from volcanic areas. In general levels were comparable or lower than those reported in other countries, possibly with the exception of iron in livers. Cadmium and mercury levels in organs from animals living close to Mount Hekla (erupted during collection of samples) also showed no elevated levels.

Conclusions

- Analytical results provided by the Institute of Earth Sciences; University of Iceland have shown that the ashes in the proximity of the volcano consist mainly of silicon-oxide and aluminum-oxide. Several other minerals (oxides) were found in relatively high amounts (calcium, manganese, magnesium, iron, sodium, potassium, titanium and phosphorous. Together these comprised 99.7% of the analysed material (range: ~ 2.7 – 577 g/kg). Other elements which have been identified are Ba, Co, Cr, Cu, Ni, Sc, Sr, V, Y, Zn and Zr which comprised 0.16% of the analysed material (range; ~ 16 – 460 mg/kg). No data were provided as to the chemical speciation of these elements. In addition to these, also 23-35 mg of soluble fluoride/kg was found. Based on the composition of the volcano ashes, it can be concluded that ingestion of 100 mg of ash per day would not result in damage to health, for any of the elements found. This is a lower bound estimate based on worst case assumptions with respect to release and bioavailability of the elements from the ash matrix. The 100 mg lower bond estimate is driven by the high level of aluminum-oxide in the volcano ashes. However, the amount of aluminum in the ashes is not significantly higher than in Dutch soil for which no risks are known. Other elements which would put a significant limit to the maximum amount of ash that can be safely ingested (100 – 400 mg/d) are Scandium (Sc), Yttrium (Y) and Zirconium (Zr), but the assessment procedure for these elements probably overestimates the risk. No specifically low maximum intake of ashes was identified to prevent excessive exposure to fluorine.
  Foraging animals may ingest a large amount of soil. However, based on the comparison of the reported composition of the Icelandic volcanic ash with the composition of Dutch soil, no significant change in Dutch soil composition is expected as a result of the deposition of this ash. Consequently no health risk or risk for significantly altered transfer of ash components into animal tissues is anticipated.

- There are no indications that significant deposition of these ashes onto edible crops or feed has occurred. Limited data available, based on rainwater sample analyses, indicate that the amount of minerals deposited onto Dutch soils is negligible in comparison to the background concentrations of these minerals.

- Rainwater samples collected in the Netherlands have been analysed. In addition dust collected from airliner surfaces has been studied. The first results of the investigation of rain samples indicate that concentrations of a few elements in rain were slightly higher than in rain samples from the period before the eruption (2006-2009). However, the concentrations were well-within the normal ranges. It may be concluded that some minimal deposition from this rain fall has occurred. The ash samples collected from airliners showed no presence of fibrous material.

- At this moment, in the Netherlands there are only few vegetables grown outdoors. These are late winter vegetables such as leeks or kale, and early spring vegetables such as spinach. There are no harvestable fruits. In later spring, fruits (e.g. strawberries, raspberries, red currants) will be harvested and also the number of outdoor-grown vegetables will increase (e.g. lettuce, endive). As deposition of ashes is currently hardly detectable, there is no need to wash fruits or vegetables more rigorously than normal.

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Annex I.

Reference values for minor components in Volcanic ashes from Iceland

Table 4. Overview of reference values used for the safety assessment of exposure to various metals from mineral clays.

Ref. values	**Ba**	**Co**	**Ni**	**Sc**	**Sr**	**V**	**Y**	**Zr**	**F**	**P**
Type (unit)	MRL	i-MRL	TDI	TDI	MRL	iMRL	TDI	TDI	UL	"safe level
Value [*]	0.2 mg/kg bw/d[a]	0.01 mg/kg bw/d[b]	0.02 mg/kg/day[c]	0.5 µg/kg bw/d[d]	0.6 mg/kg bw/d[e]	0.01 mg/kg bw/g[f]	0.5 µg/kg bw/d[d]	0.5 µg/kg bw/d[g]	120 µg/kg bw/d[h]	"3000 mg pppd[j]
Effect	Nephrotoxicity	Polycytemia; inhal ref val: 0.1 µg/m3 decr resp funct.	For nickel soluble salts. decreased body weight and organ weight	Growth retardation; tentative value	Skeletal toxicity	Blood pressure, haematology.	Growth retardation; tentative value	Tentative value; based on.	At higher dose levels haemosiderosis[i]	No specific effect set

Ref. values	Al	Cr (III) insoluble	Cr (III), soluble and Cr(VI)	Fe	Cu	Zn	Mn	Mg	Na	K	Ca
Type	TWI	RfD	TDI	pTDI	TDI	UL	UL	UL	TV	SL	UL
Value (unit)	1 mg/kg bw/wk[k]	5 mg/kg bw/d[l]	5 µg/kg bw/d[l]	0.8 mg/kg bw/d[h]	83 µg/kg bw/d[i]	360 µg/kg bw/d[i]	11 mg pppd[m]	250 mg pppd[i]	2.4 g/pppd[n]	3000 mg pppd[i]	2500 mg pppd[i]
Effect	testicular toxicity neurotoxicity	no effects observed at highest dose tested	no effects observed at highest dose tested	adverse effects associated with iron overload	Histo-pathological changes in forestomach, liver and kidney, effects on liver function	perturbation of Cu homeostasis	No specific effect at higher exposures was indicated	Diarrhoea.	Hypertension. An ADI or UL is not available. The target value is a practical guide which will not result in excessive hypertension	No specific limit set; the value of 3000 mg pppd was reported to be without effect. At higher levels conductive effects and compromised heart function	No effects observed in epidemiologi cal studies

Ref. values	Ti
Type (unit)	ADI
Value	"not specified"[o]
Effect	ADI applies to the oxide. "not specified" because of no absorption.

[a] ATSDR, 2007; [b] ATSDR, 2004a; [c] ATSDR, 2005; [d] Verweij *et al.* 1994, De Boer *et al.* 1996; [e] ATSDR, 2004b; [f] ATSDR 2009; [g] Schroeder *et al.* 1968; [h] JECFA, 1983; [i] EFSA, 2006; [j] EFSA, 2005; [k] EFSA, 2008; [l] Baars *et al*., 2001; [m] ATSDR, 2008b; [n] Health Council of the Netherlands, 2006; [o] EFSA, 2004.

* Abbreviations used: TDI = tolerable daily intake, pTDI = provisional tolerable daily intake, UL = upper level, (i)MRL = (intermediate duration) mimimum risk level, RfD = reference dose, TWI = tolerable weekly intake; SL: "safe level"; TV: "target value" for explanation of SL and TV: see text.