[redacted]

From: digital.services=[redacted] on behalf of [redacted]
Sent: Wednesday, 13 July 2022 7:04 AM
To: DPIE Water Greater Metro GW WSP Mailbox
Subject: Submission for the draft replacement Greater Metropolitan Regional Groundwater Water Sharing Plan

Permission	
I give permission for my submission to be publicly available on the NSW Department of Planning and Environment website:	Yes
I would like my personal details to be treated as confidential?:	No
Your details	
1. Name:	[redacted]
2. Email address:	[redacted]
3. Address:	[redacted]
4. Contact phone number:	[redacted]
5. Are you an individual or representing an organisation?:	Individual (Go to Question 7.)
6. If you are representing an organisation, what is the name of the organisation?:	
7. Which stakeholder group best describes you?:	Environment
8. If you selected other, please specify:	
Your feedback	
9. Did you attend a Greater Metropolitan Region Water Sharing Plan public webinar, a public face-to-face meeting or have a meeting with the department about the water sharing plan?:	None of these
10. Does your feedback refer to a specific water source?:	No
Your feedback	
11. Do you support the amalgamation of the groundwater sources?:	Yes
11(a). Please provide a reason for your support/opposition.:	Ease of graft
12. Do you support the changes that increase or decrease the borders of groundwater sources?:	No
12(a). Which ones/why?:	Don't need to help frackers
13. Do you support or oppose the changes that separate groundwater sources from underlying groundwater sources of a different geology?:	Yes
13(a). Which ones/why?:	Smart water alternatives better than using aquifers
Your feedback	
14. Do you support the proposed LTAAELs?:	No
14(a). Please provide a reason for your support/opposition.:	Graft driving it
Your feedback	
15. Do you support the proposed changes to the high priority groundwater dependent ecosystems in the plan?:	No
15(a). Please explain why/why not?:	Graft driving it
Your feedback	
16. Do you support allowing Aboriginal Community Development Licences in select areas?:	No

16(a). Please explain why/why not?:	Limit of water applies to all
Your feedback	
17. Do you support/oppose changes to the access rules?:	No
17(a). Why/why not? A specific rule or the rules in general?:	Graft driving it
Additional feedback	
18. Comments on any aspects of the draft plan:	Ban tracking
Additional attachments	
Or, you can attach your documents here::	No file uploaded

Greater Metropolitan Water Sharing Plans

Email: greatermetroGW.wsp@dpie.nsw.gov.au

C/- [redacted]

P.O. Box 2213

Dangar NSW 2309

Dear Sir/Madam,

Re: [redacted]

In reply to your invitation to have my say in relation to the proposed changes to the water sharing plan for the Greater Metropolitan Region Groundwater Sources 2011, I wish to advise that:

I have a bore registered/licensed, which is used for livestock watering during drought periods.

I have a pump connected to Little Cattai Creek which pumps to a holding tank of approximately 18,000lt to gravity feed all livestock water troughs on the property as well as a pressure system used on the house garden . I have an irrigation system from the creek to water 4 hectres (10 acres) the irrigation system is only used on rare occasions as the seasons dictate

I have owned the property since 2001. The irrigation and watering system was in existence when I purchased the property and there has been no change. The Pump has been on the creek for more than 80 years and has been used for irrigation of crops as well as livestock watering.

I also have a large water mass 'filtration pond' referred to by council as swamp. It goes up and down with the water table and it is affected by floods and droughts. It is a very shallow water mass and birdlife come and goes. Nothing lives on this area permanently and there is no vegetation it is like a dry spot for much of the time. It is not a dam and we do not pump water out of it, the area fills with floods and then dries out in drought.

As there has been no change to the watering system on the creek from my property for more than 80 years, I consider, there is no justification to make any changes.

Should you wish to discuss my property needs and usage, please feel free to contact me at anytime.

Yours faithfully

[redacted]

6 August 2022

From: [redacted]
To: DPIE Water Greater Metro GW WSP Mailbox
Subject: Blue Mountains Consultation
Date: Saturday, 13 August 2022 10:39:28 AM

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hello [redacted]
Thankyou for the good discussion we had with you and your colleagues in katoomba.

Unfortunately the extent of consultation with our community was seriously limited by:

1. lack of advertising - I didn't see any public notices or articles in local paper, and have spoken to many people since who would have liked to have been involved. Someone just forwarded me an email. Have you made contact with Blue Mountains City Council? There is an environmental section that has been involved in groundwater issues for many years.

2. locked doors at RSL building - One person attempted to get in sometime between 10 and 11 and couldn't ..and gave up as there was no sign about the session and noone to let him in. Another was waiting well over 10 mins to be let in.
I got in with an employee of the club. When one of the dept people appeared to show me where the room was I specifically asked him if someone would stay at the door and let in residents - he obviously didn't.

I hope DPE practices can improve in the future and maybe an article in the local paper about the issues may assist even now... (with an extension) ?

--
regards
[redacted]

tadpai

Tarago and District Progress Association Incorporated

[redacted]

Email: [redacted]@[redacted]

"Promoting the Social and Economic Development of Tarago Village and District"

16th August 2022

[redacted]
Greater Metropolitan Water Sharing Plans
NSW Department of Planning and Environment
PO Box 2213,
Dangar NSW 2309

[redacted]

RE: REVIEW AND FEEDBACK ON DRAFT WATER SHARING PLAN FOR THE GREATER METROPOLITAN REGION GROUNDWATER SOURCES 2023

References:

A. NSW Planning and Environment Draft Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023
B. United Nations Environment Programme's Waste to Energy - Considerations for Informed Decision Making, 2019
C. NSW Government's .Energy from Waste Infrastructure Plan - Supporting the NSW Waste and Sustainable Materials Strategy 2041, September 2021
D. NSW EPA Regulation: Protection of the Environment Operations (General) Amendment (Thermal Energy from Waste) Regulation 2021 dated 8th July 2022
E. NSW Contaminated Land Management Act 1997 No 140 dated 4th March 2022

Preliminaries

The Tarago Community comprises the people who live in the village of Tarago, and those on farms and farmlets in the Tarago and surrounding districts. The Tarago Community is split across the local government areas of Goulburn-Mulwaree, and Queanbeyan-Palerang. Our Community is split across the boundaries of the State Goulburn and Monaro Electorates, and across the Commonwealth Hume and Eden-Monaro Electorates.

The Tarago Community is essentially a mix of farmers and graziers, and those seeking a rural lifestyle, with the latter being divided between retirees and those who commute for employment to and from Queanbeyan/Canberra or Goulburn on a daily basis. This includes people and families who have moved to the area for health reasons.

Children commute to and from school in all directions: Tarago, Goulburn, Bungendore, Braidwood and Queanbeyan/Canberra via parents and buses.

Tarago and its Community reside within Sydney's Greater Metropolitan water catchment area. The water from our district passes through numerous communities on its way to Sydney's water catchment dams. The local agricultural businesses are dependent on the availability of clean potable water for their crops and animals. It is for these reasons that TADPAI on behalf of the Tarago Community is submitting its observations of the Draft Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023 (Reference A) for your consideration.

Protection of the Environment Operations (General) Amendment (Thermal Energy from Waste) Regulation

It is an accepted fact that Energy from Waste facilities emit toxic and polluting emissions, and the residual ash is both toxic and highly soluble. The United Nations now promotes that all developed countries should avoid the use of Energy from Waste, and in particular via vaste incineration for health and ecological reasons. See Reference B. Indeed a number of countries have commenced banning the use of waste incineration technology.

The NSW Environment Protection Authority and the NSW Chief Scientist jointly agree that Energy from Waste facilities do provide a level of risk to human and ecological health (See Reference C). And on this advice, the NSW Government has recently passed into legislation the Protection of the Environment Operations (General) Amendment (Thermal Energy from Waste) Regulation (Reference D). In which, the Government is seeking to initially limit the number of locations to build and operate Energy from Waste facilities to four regions; of which two (the West Lithgow Precinct and the Southern Goulburn Mulwaree Precinct) reside in Sydney's water catchment area.

Veolia is proposing to build and operate its Advance Recovery Centre (ARC) within the Woodlawn Eco Precinct within the Southern Goulburn Mulwaree Precinct. This ARC is an Energy from Waste (via waste incineration) facility; it will release into the air quantities of dioxins, furans and other toxic/polluting chemicals. Veolia is also proposing to bury on site the toxic and highly soluble residual ash that is generated through waste incineration.

Based on experiences and evidence from overseas the emissions from waste incineration will over time pollute the surface water that recharges groundwater volumes. The burying of toxic and highly soluble ash has the potential to leach into groundwater; and the problem with this risk is that it can occur unnoticed and its presentation too late to fix.

tadpai

Tarago and District Progress Association Incorporated

[redacted]

Email: [redacted]@[redacted]

"Promoting the Social and Economic Development of Tarago Village and District"

Intergenerational Equity and Polluter Pays

Clause 9(3)(b) of the Contaminated Land Management Act 1997 No 140 (Reference E) states: "*inter-generational equity—namely, that the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations*".

Clause 9(3)(d)(i) of the Contaminated Land Management Act 1997 No 140 (Reference E) states: "*polluter pays—that is, those who generate pollution and waste should bear the cost of containment, avoidance or abatement*".

Protecting Sydney's Groundwater Supplies

Based on the above two legislated principles that the following should occur.

Schedule 2 Contamination sources of the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023 should be amended as follows:

> *.Contamination sources are as follows—*
> *(a) a site declared to be significantly contaminated land within the meaning of the Contaminated Land Management Act 1997,*
> *(b) a site notified to the Environment Protection Authority under the Contaminated Land Management Act 1997, section 60,*
> **(c) the approved Energy from Waste precincts listed within the Protection of the Environment Operations (General) Amendment (Thermal Energy from Waste) Regulation 2021 or other locationsas approved by the Minister.**

The Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023 should also be appropriately amended to:

- prohibit the burying of all hazardous waste, including waste incineration ash, within the Sydney Greater Metropolitan water catchment area;
- require known and potential industrial emitters of pollutants to undertake real time monitoring, reporting and publishing of all activities that could potentially adversely impact on Sydney's groundwater supplies; and
- require known and potential industrial emitters of pollutants to have in place real, doable and funded contingency plans to remediate and rehabilitate any groundwater contamination.

tadpai

Tarago and District Progress Association Incorporated

[redacted]

Email: [redacted]@[redacted]

"Promoting the Social and Economic Development of Tarago Village and District"

Thank you for giving the Tarago Community an opportunity to comment on the Water Sharing Plan.

Yours Sincerely

[redacted]

[redacted]
TADPAI
[redacted]@[redacted]

[redacted]

20 August 2022

Department of Planning and Environment – Water
Greater Metropolitan Surface Water WSP
Locked Bag 5022, PARRAMATTA NSW 2124
GreaterMetroUnreg.WSP@dpie.nsw.gov.au

Sydney Water's submission on the draft Greater Metropolitan Water Sharing Plans

Thank you for the opportunity to comment on the draft replacement *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Sources 2023* and the draft replacement *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023*.

We support the overall intent of the plans, and the work that has been done to improve and simplify them.

Sydney Water operations and context of our comments

Sydney Water is Australia's largest utility, supplying water, wastewater and some stormwater services to over five million customers across Greater Sydney and the Illawarra. We source bulk water for our customers from WaterNSW, who manage Greater Sydney's water supply catchments. Most of the water we use is sourced from Warragamba Dam and the Upper Nepean Dams, but we also extract water from the Hawkesbury Nepean River at North Richmond, and water is transferred from Tallowa Dam on the Shoalhaven River in times of water scarcity.

We also treat and safely discharge customers wastewater. Around 15 percent of our city's wastewater is treated to a very high level and released to the Hawkesbury Nepean River. This proportion may grow as more people live and work in the Western Parkland City.

Sydney Water has operated the St Marys Advanced Water Treatment Plant for over 10 years. This plant returns very high-quality recycled water to the Nepean River below Penrith Weir to replace water that was previously released from Warragamba Dam for the environment and downstream users.

We will be constructing the Upper South Creek Advanced Water Recycling Centre which will begin servicing customers in western Sydney from 2025. This plant will also provide very high-quality recycled water.

We are also responsible for stormwater trunk drainage that serves approximately 15 percent of our customers. We have recently been declared as the trunk drainage manager for the rapidly developing Mamre Rd and Aerotropolis areas.

Sydney Water's overall comments on the plans

We believe the draft replacement Plans are a significant improvement on the existing Plans. We support:

[redacted]

- the rationalisation of the Plan objectives, the clear strategies identified to achieve objectives, and identification of indicators which will allow Plan success to be measured
- simplification of the plan and consolidation of administrative units
- clear rules that recognise replacement flows from St Marys Advanced Water Treatment Plant and recognition within the background document of the benefits that Upper South Creek Advanced Water Recycling Centre return flows can deliver
- improved oversight of annual major utility extractions, and the impetus this may provide for enhanced urban water conservation efforts.

There are still some gaps in the Plans and supporting policies, and we urge rapid attention to issues such as:

- the potential impact of changed harvestable rights allowances on licenced extractions. We strongly advocate that any subsequent changes to licenced extraction must not reduce major utility entitlements.
- The need for the surface water Plan to recognise return flows from Upper South Creek Advanced Water Recycled Centre whether or not Warragamba Dam variable environmental flows are in place by 2025.
- development of a supporting stormwater harvesting policy and related plan rules to enable the plan to deliver key elements of the Greater Sydney Water Strategy and respond to Natural Resources Commission recommendations.

We look forward to working with DPE and Water NSW to progress key elements of the Plan and identified next steps, including:

- establishing sustainable long term average annual extraction limits that consider the impacts of climate change on streamflow and rainfall reliability. We appreciate the impetus this provides to progress GSWS priorities of robust rainfall independent supply and enhanced water conservation.
- development of an appropriate monitoring, evaluation, reporting and improvement (MERI) program, that can assess how well environmental objectives have been achieved, and measure performance indicators.
- completion of a robust stormwater harvesting policy, and update of the surface water plan with supporting rules.
- improvements to gauging and data sharing so the surface water plan can be more effectively implemented and regulated.
- continuing our discussions with DPE to explore ways of improving and simplifying approvals for temporary groundwater extractions. We have also suggested approaches to managing these extractions within the groundwater plan.
- quantifying and recognising the return flow benefits and values created by all well treated wastewater discharges (whether or not they are reverse osmosis treated).

[redacted]

The “next steps” section of the background documents for the plans represents a significant work program. It must be managed and resourced properly to ensure both plans achieve their long-term objectives.

Please see our detailed comments on the draft replacement *Water Sharing Plan for the Greater Metropolitan Region Unregulated River Sources 2023* in **Attachment A** and our detailed comments on the draft replacement *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023* in **Attachment B.**

If you have any questions about our submission, please contact [redacted] Strategic Planning Manager – Healthy Waterways and Environment at [redacted]

Yours sincerely

[redacted]

[redacted]
Head of Strategy and Enterprise Planning
Sydney Water

[redacted]

Attachment B: Sydney Water submission to the Draft Replacement Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources

Part 1: Introduction

We support the administrative boundary changes made to the Plan and the amalgamation of some existing groundwater sources as shown in the map, which reduce the number of groundwater sources from 13 to 10. The boundary change of most relevance to Sydney Water is the amalgamation of the Sydney Basin West Groundwater Source, which combines the former Sydney Basin Blue Mountains, Sydney Basin Cox River and Sydney Basin Richmond groundwater sources.

Sydney Water supports the Plan's recognition of layers of "stacked" groundwater sources.

We also support the addition of reclaimed land, areas under water bodies (beneath dams, rivers, and lakes), and hanging swamps to the mapped area and as this provides more holistic coverage of groundwater sources.

We also support the efforts Department of Planning and Environment (DPE) has made to improve links between the two Greater Metropolitan water sharing plans, for example the limits to extraction from water supply works on waterfront land when take from a nearby surface water source is prohibited.

Maps

Sydney Water is pleased that maps have been created for the High Priority Groundwater-Dependent Ecosystem (GDE) and Coastal Wetlands and Littoral Rainforest Area Map.

Sydney Water requests these maps be made available as a spatial layer to allow users to zoom in and interrogate in even greater detail and enable more accurate assessment of areas of interest against High Priority GDEs.

Sydney Water understands from previous discussions with DPE that this map is based on a combination of the high priority list in the Water Sharing Plan plus high and very high priority GDEs based on the High Ecological Value Aquatic Ecosystem (HEVAE) framework.

Sydney Water requests further information about how these maps were developed, and clarification on whether they will replace all other NSW Government GDE mapping for this area.

Part 2: Vision, objectives, strategies, and performance indicators

We support the vision, objectives, strategies, and performance indicators outlined in Part 2. In general, we support continuation of the "no more than minimal harm" requirement as the threshold for allowing extraction in a way that satisfies the objectives of the Plan.

In regard to Objective (b) "to maintain and, where possible, improve access to groundwater to optimise economic benefits for agriculture, groundwater-dependent industries and local

economies, we note the potential demand for groundwater from the Leonay-Wallacia bore fields as an emergency drought supply option for Sydney.

The draft Greater Sydney Water Strategy notes that “bore fields will still continue to play a limited but meaningful role in drought management, providing up to 30 GL/year”. The GSWS will drive more detailed drought planning, including having options at-the-ready to respond quickly when drought conditions return. Accessing groundwater as an emergency drought water supply was first considered in 2004 during the Millennium drought, and this option was specifically included in the 2017 Metropolitan Water Plan.

This potential demand must be identified in the Plan.

Part 3: Requirements for water

We support the method DPE has used to update estimates of water requirements, including

- data on the number of bores used for domestic and stock rights and estimates of demand for these uses
- land-use changes (that will likely lead to a decrease in demand in urban areas and an increase in demand for rural lands in the west of the Plan area, particularly during drought)
- access licence data, including licences issued under controlled allocations

Major utility requirements for temporary construction dewatering

Sydney Water builds and manages essential water, wastewater, recycled water and stormwater infrastructure across much of the area covered by the Greater Metropolitan Region Groundwater Sources Water Sharing Plan. Temporary groundwater extraction is sometimes incidental to these activities, where groundwater flows into excavations when we renew, rehabilitate or build these assets. Groundwater is not generally used for consumptive purposes, unless for dust suppression via tanker. Depending on water quality, the extracted groundwater is discharged to stormwater, sewer or returned to the same source through reinjection down-gradient of the construction work.

Temporary dewatering activities where small volumes of groundwater are taken incidentally are of short duration and therefore present low risk to the water resource and environment. Under Division 5.1 of the *Environmental Planning and Assessment Act 1979*, Sydney Water considers the environmental impacts of our activities (including for example, proximity to coastal wetlands) and adopts safeguards to minimise potential impacts.

Under current rules, Sydney Water needs to obtain water supply works approvals and for extractions >3ML (specified in the exemptions in clause 7, Schedule 4 of the *Water Management (General) Regulation 2018*. Sydney Water therefore obtains water access licences and/or trades water shares. These processes impose a large administrative burden and cost (often exceeding the purchase price of the water).

These processes also impose lengthy project delays for works that are typically short-term and temporary groundwater extractions. There is also a risk that essential infrastructure is unable to be delivered if water shares are exhausted or unavailable for trade. Sydney Water is currently working with the Department of Planning and Environment to establish legislative

exemptions for these activities and requests that consideration be given to whether these exemptions can be enabled through the Water Sharing Plan. We also suggest the demand for water as a result of these essential construction activities be embedded in Plan calculations, as other forms of take, such as basic landholder rights, are. We also note that the replacement Plan may be amended to the better enable management of aquifer interference activities, including the granting of aquifer interference approvals.

Part 4 – Limits to the availability of water

We support the numerical definition of long term average annual extraction limits (LTAEELS) for each water source and we believe this will improve transparency and accountability.

Sydney Water supports the proposed changes to metropolitan groundwater extraction limits that incorporate rainfall data and updated information about risks, including climate risks.

Part 5: Rules for granting licences

Specific purpose access licences

As a major water utility, Sydney Water incidentally extracts groundwater when we maintain and build our assets. We are working with DPE to broaden exemptions and streamline approvals for this form of temporary groundwater take.

We also note that specific purpose access licences, as discussed in s21 could be a useful approach to broadly regulate Sydney Water's aquifer interference as a result of temporary construction activities across an entire groundwater source. This would potentially enable better quantification and long-term management of water extracted through these activities, and potentially enable beneficial water inputs to be accounted for. We consider that specific purpose access licence for this purpose s could be issued under the environmental or major utility categories.

Part 7: Construction and use of water supply works

Extraction from contaminated groundwater sources

We note that the draft replacement plan includes rules restricting new or amended water supply works approvals near:

- coastal wetlands
- land classified as having a high probability of containing acid sulphate soils
- mapped high-priority groundwater-dependent ecosystems
- contamination sites
- on-site sewage disposal systems.

We also acknowledge that water supply construction conditions in the draft replacement plan require the approval holder to ensure the construction and use of the work prevents contamination of the aquifer or between aquifers.

We note that the restrictions on water supply works near contamination sites do not apply if the Minister is of the opinion that the location of the water supply work is adequate to protect the groundwater source, the environment, and public health and safety, or the water supply

work is for the purpose of monitoring, environmental remediation activities or emergency services. We also note that restrictions on water supply works on land with a high probability of acid sulfate soils do not apply if there isn't likely to be a significant risk of acidification of the groundwater sources.

Sydney Water may sometimes need to extract water from or near contaminated groundwater sources when constructing or maintaining pipes and other assets. Therefore, we request clarification on the exceptions that apply to this form of extraction when groundwater could be treated (if required) before disposal.

High priority groundwater-dependent ecosystems

Sydney Water also notes the restrictions on water supply works that may affect high priority groundwater dependent ecosystems, including water supply works on waterfront land (that includes the bed and bank of any river, lake or estuary and all land within 40 metres of the highest bank of the river, lake, or estuary).

We request clarification on the exceptions to these restrictions, including for replacement groundwater works, monitoring, environmental remediation activities or emergency services, or if the Minister's opinion is that the location of the water supply work is likely to cause no more than minimal harm.

We note that access rules continue to apply to extraction under an aquifer access licence from water supply works approvals on waterfront land.

Groundwater- dependent culturally significant areas

It would be useful for the water sharing process to refer to information on Aboriginal cultural values that DPE- EHG is using to update the NSW Water Quality Objectives.

Sydney Water would like to be informed when groundwater-dependent culturally significant areas are identified (e.g., for Aboriginal community development) and how they will be documented.

Part 8: Access licence dealing rules

Sydney Water notes the intention to remove exemptions in the current Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources 2011, that provide some users with access to very low flows – in order to better protect environmental water in very dry times.

We note that DPE is planning to delay the removal of these exemptions, because many potentially affected groundwater licence holders have also been affected by recent floods along the Hawkesbury Nepean River. We understand that an amendment clause in the Plan will enable it to be updated within the life (likely mid-way) of the Plan,

Sydney Water strongly recommends that future restrictions on extraction during very low flow periods do not apply to our construction works and associated temporary groundwater extraction. The volume of water taken during these activities is minor compared to

permanent extractions, is likely to be reduced during drought times when soil moisture levels are low, and is incidental to the operation of essential water infrastructure.

As noted elsewhere in this submission, managing short term groundwater extraction (including the administrative effort) when we renew, rehabilitate or build our assets can be time consuming, and we are working with DPE to identify opportunities for exemptions and streamlined approvals.

We also note exception to access rules if the extraction does not impact baseflows in the river, and exception to existing access for town water supply.

Trade

We rely on an efficient and transparent groundwater market to purchase entitlements when required for incidental groundwater take that occurs as a result of construction activities.

We strongly support trade rules that enable the Plan to achieve objective b “to maintain and where possible improve access to groundwater to optimise economic benefits”, and deliver upon strategy (c) “provide for trade of water allocations” (d) provide a stable and predictable framework for sharing water and (e) providing flexibility of access to groundwater. We will continue to rely on trade until more exemptions or streamlined approvals are made.

While we understand there are no changes to trade rules in the replacement Plan, Sydney notes that amalgamation of the Sydney Basin Blue Mountains, Sydney Basin Coxs River and Sydney Basin Richmond groundwater sources into the Sydney Basin West Groundwater Source allows for trade between areas which was previously prohibited. We support this change.

Part 9: Mandatory conditions

Water supply work decommissioning condition

This condition appears to be applicable for ongoing Water Supply Works (e.g., bores).

Sydney Water suggests that this condition clarifies the rule does not apply to temporary Water Supply Works (e.g., pumps required for temporary construction work).

Part 10: Amendment of this plan

The surface water plans identify they can be amended to add provisions related to management of waters in coastal sands, managed aquifer recharge, the management of aquifer interference activities, the protection of groundwater dependent culturally significant areas. This list of potential additions illustrates the links between the two Plans.

Similarly, Clause 54 e ii of the Ground Water Sources Water Sharing Plan also specifies that you may add or modify provisions relating to the management of waters in coastal sands, managed aquifer recharge, the management of aquifer interference activities, including the granting of aquifer interference approvals, (v) the protection of groundwater-dependent culturally significant areas, the plan may be amended for (ii) managed aquifer recharge,

Further work

We need to better understand:

- Links to NSW's draft Groundwater Strategy that has recently been circulated for review. It will be useful to understand how the strategy will drive ongoing monitoring of the replacement plan, and future updates of it.
- Connectivity between surface and groundwater sources.
- Strengthen groundwater monitoring to improve understanding of the impact of groundwater extractions from mining and other extractive industries, and what this means for surface water availability.
- The potential impact and ongoing management of not- yet-recognised contaminants, chemicals of concern and microplastics on groundwater quality.
- The impacts of catchment land use change on local groundwater recharge and the maintenance of baseflows in streams. We also need an improved understanding of the role enhanced stormwater harvesting and retention can have in addressing some of these changes. The NRC report cites that “changes to stormwater harvesting policy will particularly affect water sources with urban growth and consolidation such as western Sydney, and downstream systems. Stormwater
- harvesting, combined with filtration, infiltration and irrigation, can reduce runoff volumes for the majority of storm events to close to pre-development levels, while also helping restore baseflows, return natural soil moisture levels to urban landscapes and maintain water quality.
- The impact of climate change on both surface and groundwater sources for example in the recently released “ACT Water Strategy – Striking the Balance” notes that run-off into water supply dams could fall by as much as 40% due to climate change.
- Opportunities of Integrated Water Cycle Management such as the role of stormwater reuse and harvesting to regulate flows in waterways as well as reducing potable water consumption.
- Potential future opportunities (benefit, technical viability and costs) of aquifer recharge. In times of surplus, well treated recycled water or stormwater can be pumped underground to be stored in a suitable aquifer where it can be accessed when needed. The most well known aquifer in the Sydney region is the Botany sand aquifer located between Centennial Park and Botany Bay. The hydrogeological characteristics of the north-eastern Botany aquifer (Botany Sands) have been assessed as suitable for managed aquifer recharge (MAR) systems to extend available water resources, although these concepts would need more detailed hydrogeological studies and groundwater modelling.

Blue Mountains Conservation Society Inc

[redacted]
Phone: [redacted]
E-Mail: [redacted] Web Site: www.bluemountains.org.au

Nature Conservation Saves for Tomorrow

Greater Metropolitan Region Water Sharing Plan
Dept Planning and Environment – Water
PO Box 2213
Dangar NSW 2309

GreaterMetroGW.WSP@dpie.nsw.gov.au

20 August 2022

Re: Greater Metropolitan Region Groundwater Sources Water Sharing Plan

The Blue Mountains Conservation Society (the Society) is a community-based volunteer organisation with over 900 members. Our mission is to help protect, conserve and advocate for the natural environment of the Greater Blue Mountains. In fulfilling its mission, the Society advocates for the protection of the Greater Blue Mountains World Heritage Area.

This submission is made in response to the public exhibition of the draft replacement of the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023 (the Draft Plan). We note that the Draft Plan proposes to amalgamate the Sydney Basin Blue Mountains groundwater sources with others, to form the Sydney Basin West Groundwater Source. However, the Society submits that there are some unique features relating to groundwater sources within the Greater Blue Mountains, which should be recognised in the Draft Plan and/or other legislation.

1. GROUNDWATER DEPENDENT ECOSYSTEMS IN THE BLUE MOUNTAINS

The Blue Mountains is home to unique and fragile Groundwater Dependent Ecosystems (GDEs), including:

- Blue Mountains Swamps
- Newnes Plateau Shrub Swamps (NPSS), and
- Wet cliff-face vegetation.

Blue Mountains Swamps and Newnes Plateau Shrub Swamps are included in the EPBC-listed Temperate Highland Peat Swamps on Sandstone (THPSS) Endangered Ecological Community. In addition, NPSS are listed under the *Biodiversity Conservation Act 2016* (NSW) as an endangered ecological community, and Blue Mountains Swamps are listed as a vulnerable ecological community.

All these communities contain threatened species, for example:

- Microstrobus (*Pherosphaera fitzgeraldii*) - Wet cliff face vegetation
- Giant Dragonfly & Blue Mountains Water Skink – Blue Mountains Swamps

The Society also notes that the Greater Blue Mountains World Heritage Area has been listed for its biodiversity, which is internationally significant. This underscores the importance that adequate ground water is maintained for vegetation communities, flora and fauna that are reliant on it. Where there is uncertainty about matters such as the extent of groundwater, the amount of take or the likely rate of recharge, the Society submits that the **precautionary principle** should be applied, and every effort made to avoid potential adverse impacts, which can be 'serious, long-term and sometimes permanent'.[1]

It appears that none of the above-listed GDEs located in the Blue Mountains appear to have been listed as High-priority groundwater-dependent ecosystems in the Draft Plan.[2] The *Report card for the Sydney Basin West Groundwater Source* states that high priority groundwater-dependent ecosystems will be 'Identified at the commencement of the plan'. It is unclear what this means, or whether the above-listed GDEs will be included as high priority for the purposes of the Draft Plan. It is also unclear whether there is a further process planned for adding additional High-priority groundwater-dependent ecosystems in the Sydney Basin West area, and if so, what that process will be and whether those additional ecosystems will be added before the commencement of the plan.

It appears that without being classified as a High-priority groundwater-dependent ecosystem under the Draft Plan, there will be no specific protections in the Draft Plan for these unique and fragile areas.

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[1] NSW Government, Department of Primary Industries (Water), *Macro water sharing plans – the approach for groundwater: a report to assist community consultation* (November 2015), p 1.

[2] Note – the dictionary in Schedule 5 of the Draft Plan states that a high-priority groundwater-dependent ecosystem means an area specified in s 33(1). This is confusing and should be clarified, but it appears to refer to ecosystems listed in 'Schedule 3' or identified on the High Priority Groundwater Dependent Ecosystem Map. Schedule 3 does not appear to be relevant, and it appears this reference should instead be to Schedule 4. This should be rectified.

2. KEY GROUNDWATER ISSUES IN THE GREATER BLUE MOUNTAINS AREA

Loss of groundwater, including due to over-extraction, poses a significant risk to Groundwater Dependent Ecosystems (GDEs). In addition to threats that may affect some or all groundwater sources (including as a result of climate change),[3] loss of groundwater to supply GDEs occurs in the Blue Mountains from:

- **Cumulative impact of extraction from many domestic bores, particularly from those that are used to maintain large exotic gardens.**
  During the 2001-09 drought, a number of large "exotic gardens" flourished in the Blue Mountains area (displaying signs of 'bore water in use'), while the natural areas of bushland, including swamps, struggled.
- **Existing sewer tunnel and horizontal bores (part of the sewerage system from Mt Victoria to Winmalee).**
  Thousands of litres/sec of water is lost to the landscape by infiltration into the sewer and tunnel network potentially affecting aquifer recharge (Brown et al 2007). The inflow measured at the Lawson portal in October 1995 was 22 litres/sec (1901 m3/day).
- **Mining.**
  This includes currently operating mines on the Newnes Plateau, and historic mines which are no longer operating but continue to release groundwater. The catastrophic impact of lowering water tables as a result of longwall coal mining in the Sydney Basin has been well documented (Keith et al., In press; Mason et al. 2021; Krogh et al., In press), and highlights the extremely high risk posed to these GDEs from lowering water tables, regardless of the cause.

In addition, the Society notes that a highway bypass tunnel has been proposed for part of the Great Western Highway in the Blue Mountains. This tunnel, if it proceeds, is likely to significantly and detrimentally impact groundwater sources in the Blue Mountains and their dependent ecosystems.

The threat to these GDEs also includes a number of NSW Biodiversity Conservation Act-listed Key Threatening Processes (NSWSC 2000, 2002, 2005). These include:

- Alteration of habitat following subsidence due to longwall mining
- Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands
- Anthropogenic Climate Change

3. RECOMMENDATIONS

3.1 LANDHOLDER 'RIGHTS'

There is a lack of knowledge about the hydrogeology of the sandstone aquifers in the Blue Mountains, with many being highly localised and/or perched. The **Precautionary Principle** should therefore be applied, and the Draft Plan should reflect this.

[3] See for example, *Australia 2021: State of the Environment*, 'Inland water', page 19.

The Society submits that as a result, the “landholder’s right” to a domestic/stock bore should be withdrawn, at a minimum where it risks impacting on GDEs in the Blue Mountains.

The Society recommends:

1. The immediate re-instatement of the Moratorium on new bores, both domestic and commercial, in the Blue Mountains LGA.
2. The introduction of penalties for boring contractors who sink new or replacement bores which do not have proof of approval or other legal permission.
3. Changes in the *Water Management Act 2000* (NSW) and/or the relevant Water Plan to:
    - exempt the Blue Mountains LGA from any entitlement to a domestic bore;
    - change the condition for approval of any new application for a bore to reverse the onus of proof i.e approval should be dependent “on proof that no adverse environmental impact would be caused, including to GDEs”;
    - disallow replacement of existing bores unless the applicant can “prove that no adverse impact to GDEs would be caused”;
    - instigate a program to close down existing domestic bores in the Blue Mountains LGA.

The Society therefore objects to:

- **The provisions in the Draft Plan that permit bores to be located near any groundwater-dependent ecosystem, and particularly high-priority groundwater-dependent ecosystems**
  The Draft Plan appears to have no specific restrictions on the use of water supply works near GDEs that have not been classified as high priority, despite the vision and objectives of the Draft Plan being to protect, enhance and restore groundwater sources and their dependent ecosystems.

  The Draft Plan only restricts water supply works within 200m of most high-priority GDEs (and 500m for karst environments), which is reduced to 100m for works used for ‘basic landholder rights’ (ss 33 and 36 of the Draft Plan). It is unclear what the scientific basis is that justifies the 100 and 200m buffers, and it does not appear to be tailored to the specific features of each high-priority GDE.

- **The proposal in the Draft Plan to allow replacement of bores, where the impact is known to be damaging.**
  The Draft Plan permits water supply works to be constructed in close proximity to GDEs where they are replacement works. That is, existing bores within the 100, 200 or 500m ‘buffer zones’ of high-priority groundwater-dependent ecosystems may be replaced. Noting that these protections of vulnerable and important ecosystems are already limited and inadequate, the Society submits that these exceptions in ss 33 and 36 should be removed.

3.2 WATER RESTRICTIONS

The Society recommends that in areas where town water is available and water restrictions have been declared, these same water restrictions should apply to all 'domestic/stock' bore users.

The reasons for this are as follows:

- Risk to threatened or vulnerable communities – when water restrictions are imposed it is an indicator of the lack of aquifer recharge and therefore the vulnerability of swamps. When town water restrictions are imposed there is also likely to be greater use of groundwater, and hence less groundwater available to GDEs.
- Surface water and town water are part of one integrated system, and groundwater in the Blue Mountains area is even more scarce due to its slow rate of movement through aquifers.
- Due to the lack of information as to amounts 'domestic' users are taking (there is no metering or other reliable recording), there is a risk of over-extraction, and for this reason, continued extraction cannot be justified.
- Equity between residents, and removal of incentives to use (over-extract) groundwater.

3.3 EXTRACTION LIMITS

The Society objects to the proposed increase in the extraction limits from 25% of rainfall recharge to 70% in the Sydney Basin West Draft Plan (as set out in the relevant Report Card), for at least the Blue Mountains LGA.

The BM report card (https://www.industry.nsw.gov.au/__data/assets/pdf_file/0003/516927/sydney-basin-west-groundwater-source.pdf) states that 95% of recharge is set aside for the environment in 'high conservation value areas'. This does not appear to be defined in the Act or in the draft plan. How is this implemented?

The Society recommends that the extraction limit remains at 25% for the Blue Mountains LGA, until there is reliable information on:

- actual extraction, by requiring all bores to be effectively metered, and small amounts (which may be cumulatively significant) can be measured;
- measures of environmental impact can be reliably correlated with extraction rates.

It is unclear how various extraction losses of groundwater in the Blue Mountains area are accounted for in the modelling under the Draft Plan. For example:

- sewerage tunnel and feeder bores (including disused sewer pipes)
- disused mines (such as small coal mines in South Katoomba)
- below ground pipes & construction which interfere with aquifers, for example, building footings, and the water pipe to Cascade dam.

The Society recommends that all construction (public and private) be required to be assessed for the likelihood of interference with groundwater. If any interference with groundwater is found to be possible, an application for a licence should be mandatory, and therefore a thorough assessment under this Water Sharing Plan undertaken. An extraction licence would therefore be a requirement before any project could proceed which may potentially redirect groundwater.

The planned and proposed road tunnels through the Blue Mountains are an example of where a requirement to obtain an extraction licence would allow for a proper assessment and approval/rejection within the context of total groundwater extraction limits.

3.4 HIGH-PRIORITY GROUNDWATER-DEPENDENT ECOSYSTEMS

The Society recommends that all 3 Blue Mountains Groundwater Dependent Ecosystems (GDEs), be identified as high priority, viz :

- Blue Mountains Swamps
- Newnes Plateau Shrub Swamps (NPSS), and
- Wet cliff-face vegetation.

It is the Society's view that identification of all High-priority groundwater-dependent ecosystems should occur before the commencement of the plan. It appears that GDEs that are identified as being of 'high ecological value', and which are currently under threat of groundwater extraction are identified as being high priority for the purposes of the plans.[4]

Hatton and Evans (1998, p. 4) and Clifton and Evans (2001) identified five classes of groundwater dependence for GDEs, including ecosystems with proportional dependence on groundwater. In relation to these, they suggest that "it is likely that a unit change in the amount of groundwater will result in a proportional change in the health or extent of that ecosystem". This category included swamp heaths on the Hawkesbury sandstones in the south-eastern uplands.

Commenting on the level of groundwater dependency of wetland ecosystems, Clifton and Evans (2001) highlighted the importance of maintaining adequate groundwater levels in unconfined aquifers and adequate groundwater discharge flux for most wetland ecosystems to maintain the necessary level of wetness or waterlogging for key ecological stages: "Changes in water table level may have important implications for these communities. Prolonged lowering or raising of the water table is likely to result in changes in species composition, favouring species adapted to drier or wetter conditions, respectively". Serov et al. (2012) and the NSW Government (2002) similarly identified these Blue Mountains Swamps as GDEs and noted the high risk to these GDEs from reduction in groundwater availability.

[4] NSW Government, Department of Primary Industries (Water), *Macro water sharing plans – the approach for groundwater: a report to assist community consultation* (November 2015), p 42.

The Society submits that all Blue Mountains GDEs are covered by definition, and not mapping alone, in order that small areas not mapped can be captured. For example of the less than 3000 ha remaining of Blue Mountain Swamps, they vary in size from 0.1 ha to 70 ha. There is no possibility that all the smaller swamps can be mapped**.** They should be defined in such a way that they all remaining swamp and clifftop vegetation, irrespective of whether they have been mapped or not are captured and protected.

3.5 CLIMATE CHANGE

The threat from climate change in terms of altered hydrology, particularly from lowering of water tables, has been highlighted by various authors (e.g. Keith et al. 2010, 2014; Ramp & Chapple 2010). Reduction in groundwater availability to peat swamp ecosystems as a result of groundwater extraction for commercial or residential purposes will further compound impacts associated with a rapidly changing climate.

However, it is unclear how climate change has been taken into account for the purposes of the preparation of the Draft Plan. There is no reference to climate change in:

- the Draft Plan;
- NSW Government, Department of Planning and Environment, 'Report card for the Sydney Basin West Groundwater Source';
- NSW Government, Department of Planning and Environment fact sheet, 'A new water sharing plan for the greater metropolitan region: A summary of proposed changes included in the draft *Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023*';
- NSW Government, Department of Primary Industries, *Macro water sharing plans – the approach for groundwater: A report to assist community consultation* (November 2015).

The cumulative impact of climate change and groundwater extraction must be incorporated into any assessment of vulnerability for these GDEs. In view of the lack of detailed knowledge and characterisation of the complex hydrogeology and aquifer systems of the Blue Mountains, the Precautionary Principle must be applied.

The Society recommends that climate change should be explicitly referred to in the Draft Plan, and taken into account in the assessment of the identification of, and rules relating to GDEs. It would be appropriate to include a reference to climate change in the vision statement, objectives and/or strategies of the Draft Plan. For example, the s 8 objectives could be amended to include: 'to recognise and protect groundwater sources and their dependent ecosystems from the effects of climate change'.

Thank you for the opportunity to provide a submission to this plan.

Yours sincerely

[redacted]

[redacted]
Blue Mountains Conservation Society
Email: [redacted]

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NO MORE INCINERATORS INC

21 August 2022

[redacted]
Greater Metropolitan Water Sharing Plans
NSW Department of Planning and Environment
PO Box 2213
Dangar NSW 2309

[redacted]

RE: FEEDBACK ON DRAFT WATER SHARING PLAN FOR THE GREATER METROPOLITAN REGION GROUNDWATER SOURCES 2023

Thank you for the opportunity to provide feedback on the proposed groundwater management plan. I wish to make the department aware of changes to the management of waste in NSW that will affect the quality of ground water in NSW and which need to be taken into account in the draft plan.

Recently the NSW EPA introduced the Protection of the Environment Operations (General) Amendment (Thermal Energy from Waste) Regulation 2021 which designates four areas within NSW where dry waste can be burnt:

- West Lithgow Precinct
- Parkes Special Activation Precinct
- Richmond Valley Regional Jobs Precinct and
- Southern Goulburn-Mulwaree Precinct

In addition to these designated areas, the regulation also provides for a large number of other areas where dry waste could be burnt within the greater Sydney area and the fly and heavy ash generated by the incineration of mixed dry waste is proposed to be disposed of as “general waste” which is the lowest category of waste able to be disposed of to landfill.

The waste industry maintains that the fly and heavy ash generated by waste incineration is inert and not hazardous or can be immobilised and rendered non-hazardous. However, this is not the case as is demonstrated by the two attached papers:

- After Incineration: The Toxic Ash Problem and
- Biomonitoring of Metals in Children Living in an Urban Area and Close to Waste Incinerators

In fact, this ash which includes reagents such as lime and activated carbon contains a range of highly toxic heavy metals, e.g. manganese, lead, cadmium, copper, nickel, mercury, thallium, and vanadium and persistent organic pollutants (POPs) such as dioxins and furans that are generated whenever halogenated materials such as plastics are burnt. These heavy metals and POPs are readily leached from the ash by any surface or groundwater passing through it polluting that water stream. It has also recently been found that this ash contains large quantities of microplastics that are also easily leached from the ash by groundwater.

Furthermore, NSW EPA regulations do not effectively regulate how this material is disposed of – particularly if the material is disposed of onsite such as proposed by Veolia at their Woodlawn facility or by The Next Generation at their proposed Eastern Creek waste incinerator which is close to the Prospect Reservoir. Onsite disposal of this material makes it impossible to track or test each batch of ash and effectively circumvents the EPA’s waste tracking procedure which requires all waste to be analysed and classified before disposal.

Each batch of ash would need to be TCLP[1] tested by a NATA registered laboratory and classified before disposal and in reality, most of this ash would probably be classified as Hazardous Waste. Waste classified as Hazardous can only be disposed of in an engineered, impervious clay containment cell in a specially constructed landfill which can never be built upon.

Practice has shown that the pollutants in this ash cannot be immobilised or treated and have been shown to leach pollutants into the environment even when mixed with concrete.

Given that there are a number of waste incinerators proposed for the greater Sydney area, including the Southern Goulburn-Mulwaree area and Western Sydney that are proposing to dispose of the ash created, the Draft Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2023 should be amended to:

1) Ensure that all ash and any other waste generated by waste incineration is analysed and classified in accordance with the NSW EPA's preferred TCLP testing and tracking regime
2) Prohibit the burying of all ash generated by waste incineration except within sealed, engineered containment cells
3) Require known and potential industrial emitters of pollutants to undertake independently verified, real time monitoring, reporting and publishing of all activities that could potentially adversely impact on Sydney's groundwater supplies and
4) Require known and potential industrial emitters of pollutants to have in place real, doable and funded contingency plans to remediate and rehabilitate any groundwater contamination.

Yours sincerely

[redacted]
No More Incinerators Inc
www.nomoreincinerators.com

[1] The USEPA's TCLP or Toxicity Characteristic Leachate Procedure test is the NSW EPA's preferred methodology for the classification of waste to be disposed of to landfill.

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Article

Biomonitoring of Metals in Children Living in an Urban Area and Close to Waste Incinerators

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Abstract: The impact of waste incinerators is usually examined by measuring environmental pollutants. Biomonitoring has been limited, until now, to few metals and to adults. We explored accumulation of a comprehensive panel of metals in children free-living in an urban area hosting two waste incinerators. Children were divided by georeferentiation in exposed and control groups, and toenail concentrations of 23 metals were thereafter assessed. The percentage of children having toenail metal concentrations above the limit of detection was higher in exposed children than in controls for Al, Ba, Mn, Cu, and V. Exposed children had higher absolute concentrations of Ba, Mn, Cu, and V, as compared with those living in the reference area. The Tobit regression identified living in the exposed area as a significant predictor of Ba, Ni, Cu, Mn, and V concentrations, after adjusting for covariates. The concentrations of Ba, Mn, Ni, and Cu correlated with each other, suggesting a possible common source of emission. Exposure to emissions derived from waste incinerators in an urban setting can lead to body accumulation of specific metals in children. Toenail metal concentration should be considered a noninvasive and adequate biomonitoring tool and an early warning indicator which should integrate the environmental monitoring of pollutants.

Keywords: metals; children; toenails; biomonitoring; waste; incinerators

1. Introduction

Waste incineration in industrial plants generates bottom and fly ashes, which are released into atmosphere after appropriate purification. This procedure, however, does not completely remove toxic chemicals from the emissions. Heavy metals (manganese, lead, cadmium, copper, nickel, mercury, thallium, and vanadium in particular) cause concerns for public health [1–5]. Fly ash emitted from waste incinerators contains large amounts of metals, leading to potential ecological risk [6,7] also due to a progressive accumulation in surrounding soils [2,8]. A study investigating heavy metals in fly ash from 15 municipal solid waste incinerators showed that metals could easily leach out, mainly due to the high content of acid soluble fraction and reducible fraction. This might generate elevated environmental risk [7]. Metals are abundantly present in particulate matter produced by waste incinerators (mainly fine and ultrafine particles, PM0.2–2.5), with dominant presence of vanadium, nickel, copper, zinc, cadmium, and lead in fine particles and with magnesium, aluminum and thallium in coarse particles [5]. Fine particles emitted from waste incinerators have elevated content of heavy

metals and are more cytotoxic than those emitted from biomass incineration [9], thus contributing to human toxicity [10].

Metals can enter the human body through different routes such as dermal contact, inhalation, and ingestion [11,12]. Children are particularly vulnerable, in terms of biological effects, when exposed to metal pollution [13–17], mainly due to oxidative damage following chronic exposure [18,19]. In pediatric age, the body burden of metals has been linked with a number of pathologic conditions including nononcologic diseases (i.e., altered growth and development [20], obesity [21,22], and neurologic [23–25], cognitive [26], and respiratory [19,27] disorders) and cancer [28–30].

A recent study characterizing the distribution of heavy metals in ambient air particles (PM1, PM2.5, PM10) emitted from a municipal waste incinerator, indicated that children living close to this industrial plant had a high noncarcinogenic risk and a high lifetime carcinogenic risk following exposure to toxic metals bound to the emitted particles [28]. Several studies explored the concentration of heavy metals (mainly lead, cadmium, mercury, nickel, and chromium) in adults exposed to emissions from waste incinerators [31–36]. However, in the majority of cases a limited number of metals have been considered, and the sampling procedures were on blood and/or urine, thus mainly representing short- rather than long-term exposure [37–40]. Similarly, previous biomonitoring studies in exposed children only determined the body burden of few trace elements (mainly manganese [3], chromium, lead, and cadmium [41–43]), not considering the wide panel of metals [1,5] emitted by waste incinerators.

Thus, studies investigating the long-term accumulation of multiple metals in children living close to waste incinerators are still lacking. Furthermore, noninvasive biomonitoring tools able to determine, in this age class, the health risk deriving from the discharge of hazardous pollutants into the environment are strongly needed. In fact, human biomonitoring has been proposed as more useful to assess possible health effects than environmental monitoring [44,45]. In this respect, human nails have been frequently employed for the assessment of metal exposure of various origin [46], have been used in pediatric age [47–51], and have been indicated as suitable indicators of long-term exposures [52,53].

2. Methods

2.1. Study Design

The aim of the present study was to measure the body burden of a wide panel of metals (23 different elements, see Section 2.4) in children living in an urban setting, at different distances from two waste incinerators. According to previous evidence, the concentration of metals in toenails was employed as an indicator of chronic environmental exposure [37–39,52,53], adjusting results for possible confounders.

2.2. Study Population and Area

A public campaign served to explain the aims of the study. Subsequently, a total of 220 children (128 males, age range 6–9 years) were enrolled in the city of Forlì (Emilia-Romagna region, Northern Italy, 117,946 residents in 2017) from December 2016 to March 2017, after parents signed informed consent. Children also agreed to participate as volunteers.

Inclusion criteria were living at the same address in the last 6 months before enrollment, and the presence of a signed informed consent.

Subjects with previously known diseases were excluded from the study.

In the urban study area, two incinerators are located about 200 m from each other: a municipal solid waste incinerator (total capacity 100,000 Nm^3/h), and a hospital waste incinerator (total capacity of 21,500 Nm^3/h). Besides these two plants, according to the official emission inventories, the remaining sources of air pollution in the explored area are vehicular traffic (urban traffic, two major roadways) and domestic heating during cold season.

All enrolled children were georeferentiated. According to previous studies [28,33,41,54–57] and to results from a dispersion model specifically assessed for the two incinerators [54], exposed subjects

were considered those living within a 3 km radius circle around the two plants, with the circle centered in the middle distance between the two (Figure 1).

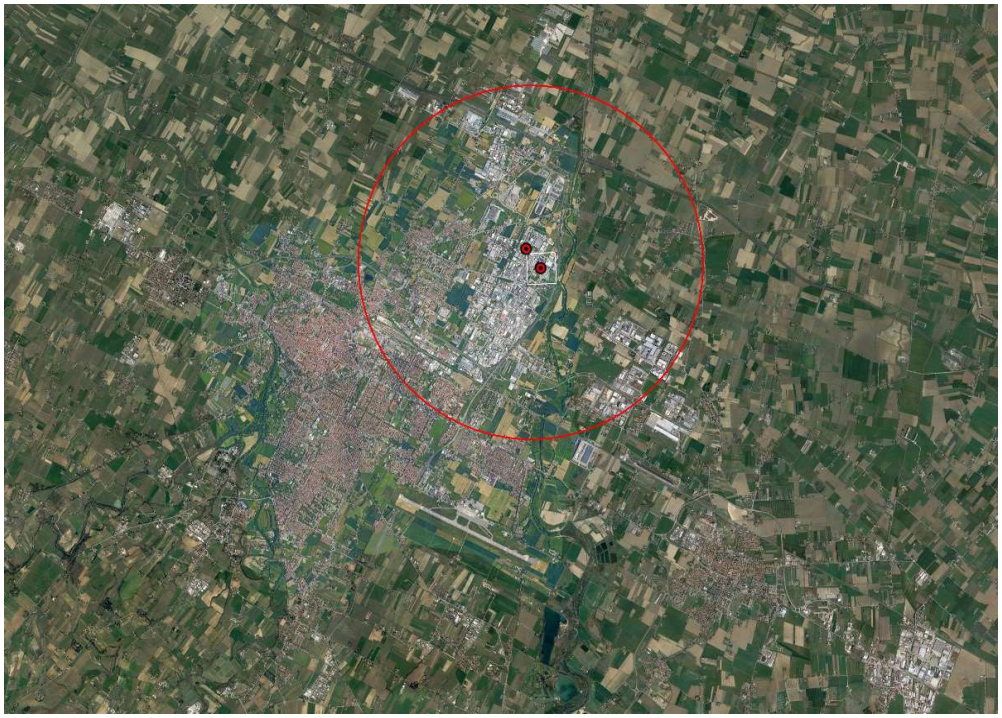

Figure 1. Study area around incinerators (filled circles), in the city of Forlì (Emilia-Romagna, Northern Italy). Exposed subjects considered were 62 children living within a 3 km radius circle around the two incinerators, with the circle centered in the middle of the distance between the two plants. A total of 158 enrolled children were residents in the remaining city areas (reference area).

Subjects in the reference area (controls) were the residents living outside this circle.

The Romagna Ethical Committee (CEROM) approved the study protocol. The initiative was entirely self-financed with popular events for fundraising or voluntary donations. Written informed consent was signed by both parents.

2.3. Assessment of Potential Confounders

A questionnaire served to explore further possible environmental conditions or personal behaviors able to influence the concentration of metals in toenails. Covariates included residential proximity (i.e., less than 300 m) to busy roads, previous orthodontic treatments, regular practice of outdoor sports, hobbies involving the use of chemicals, exposure to passive smoke, and regular consumption of locally grown vegetables. The questionnaire was administered to parents for self-compilation.

2.4. Nail collection, Sample Preparation, and Analysis

Toenails were selected for sampling as preferential to fingernails due to a minor risk of external contamination [58]. The procedures for toenail collection, sample preparation, and analysis have been extensively employed in previous studies [47,48,59–67].

Toenails were clipped using ceramic blade to avoid possible contamination. Samples were thereafter stored in a 10 mL polypropylene tube for subsequent analysis, and scissors were cleaned with a light-acid solution. Toenails were examined according to a standardized technique [68]. Briefly, samples were immersed in a 70% ethanol solution without stirring or sonication for a period of 10 min, to reduce the risk of microbiological contamination. Exogenous impurities were removed by a

multistep washing procedure with acetone and Milli-Q purified water, and the cleaned samples were kept at room temperature for a period from 24 to 48 h for drying.

The dry samples were weighed, and the concentration of 23 elements (Aluminum (Al), Antimony (Sb), Arsenic (As), Barium (Ba), Beryllium (Be), Boron (B), Cadmium (Cd), Chromium (Cr), Cobalt (Co), Iron (Fe), Manganese (Mn), Mercury (Hg), Molybdenum (Mo), Nickel (Ni), Lead (Pb), Copper (Cu), Selenium (Se), Thallium (Tl), Thorium (Th), Tungsten (W), Uranium (U), Vanadium (V) and Zinc (Zn)) was subsequently calculated, using inductively coupled plasma mass spectrometry (ICP-MS) and the EPA 6020A 2007 method.

2.5. Statistical Analysis

Frequencies of categorical variables and means and standard errors of continuous variables were calculated. The Wilcoxon test or the chi-squared test were employed to compare differences among groups. Correlations were tested using the Spearman's rank correlation coefficient. Tobit regression models were employed to examine the association between the concentration of metals and potential influencing factors. Tobit regression was also used to accommodate the left-censored nature of values, due to the presence of samples with metal concentration below the limit of detection [69]. Metal concentrations were log-transformed to meet the normal assumption [70]. P values < 0.05 were considered statistically significant.

Analyses were performed using R software version 3.5.1 (R Project for Statistical Computing, available from https://www.r-project.org/).

3. Results

According to georeferentiation, totals of 62 and 158 children were residents within 3 km from the incinerators (exposed area) and in the control area, respectively.

The concentrations of Mo, Tl, W, and U were lower than the limit of detection (LOD) in all collected toenail samples, irrespective of residence (Table 1 and Figure 2). The concentrations of As, Co, and Th were above the LOD in three (4.8%), one (1.6%) and two (3.2%) subjects living in the exposed area, respectively, but in none of those living in the reference areas. Conversely, Bo was only measurable in one subject living in the reference area.

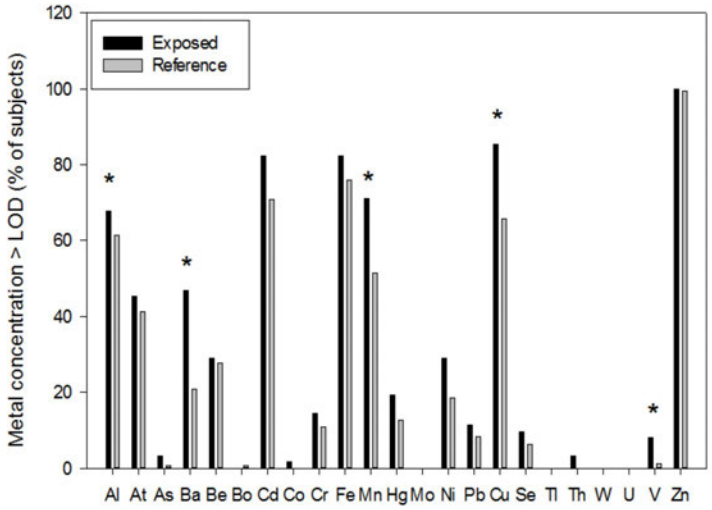

Figure 2. Proportion of children with metal concentration in toenails above the limit of detection (LOD). Children living within a 3 km radius from the two incinerators were considered exposed (n = 62). Children in the reference area (n = 158) were those living in the remaining city areas. Asterisks indicate $p < 0.01$ (chi-squared test).

As shown in Figure 2, the percentage of children with toenail metal concentrations above the LOD tended to be higher in those living in the exposed than in those living in the reference area in all cases, with significantly higher proportions for Al (67.7% vs. 61.4%, respectively), Ba (46.8% vs. 20.9%), Mn (71% vs. 51.3%), Cu (85.5% vs. 65.8%) and V (8.1% vs. 1.3%).

Table 1 shows the absolute concentrations of metals measured in the two groups of children. Children living within 3 km around the incineration plants had significantly higher concentrations of Ba, Mn, Cu, and V, as compared with those living in reference area. On average, the concentrations of these metals were, respectively, 5.5, 1.8, 1.3 and 9.5 times higher in children living in the exposed area than those in the control area.

According to results of the Tobit regression (Table 2), living in the exposed area was a significant predictor of Ba, Ni, Cu, Mn, and V concentrations, after adjusting for covariates. The analysis of covariates also showed influencing effects of previous orthodontic treatments on Ba and Cu concentrations and of exposure to passive smoke on Ba concentrations. However, the proportions of children with previous orthodontic treatments (9.7% in exposed, 10.1% in reference area, p = NS) or exposed to passive smoke (3.2% in exposed, 6.3% in reference area, p = NS) were similar in the two groups of children.

Table 1. Absolute concentrations of metals (μg/g) in toenails from children living within a 3 km radius circle around the two incinerators (exposed area) or in the reference area.

Metal	Exposed Area (n = 62)	Reference Area (n = 158)	*p*
Al	166.48 ± 50.42	103.24 ± 11.01	NS
At	0.07 ± 0.02	0.10 ± 0.02	NS
As	0.01 ± 0.01	0.00	NS
Ba	11.95 ± 9.01	2.15 ± 0.87	<0.0002
Be	0.03 ± 0.01	0.03 ± 0.005	NS
Bo	0.00	0.15 ± 0.15	NS
Cd	0.03 ± 0.004	0.07 ± 0.02	NS
Co	0.04 ± 0.04	0.00	NS
Cr	4.82 ± 3.88	1.28 ± 0.44	NS
Fe	360.08 ± 126.57	164.49 ± 21.06	NS
Mn	4.40 ± 1.23	2.47 ± 0.35	<0.05
Hg	0.05 ± 0.01	0.06 ± 0.02	NS
Mo	0.00	0.00	NS
Ni	2.23 ± 1.51	0.43 ± 0.18	NS
Pb	0.32 ± 0.13	0.95 ± 0.47	NS
Cu	6.34 ± 0.70	4.74 ± 0.36	<0.05
Se	0.01 ± 0.005	0.01 ± 0.003	NS
Tl	0.00	0.00	NS
Th	0.01 ± 0.01	0.00	NS
W	0.00	0.00	NS
U	0.00	0.00	NS
V	0.19 ± 0.11	0.02 ± 0.02	<0.02
Zn	96.27 ± 9.42	95.30 ± 3.09	NS

Legend: values are expressed as means and standard errors. NS, not significant.

Table 2. Results of Tobit regression model on metal concentrations in toenails from children living within a 3 km radius circle around the two incinerators (exposed area) or in the reference area, and the effect of covariates.

	Ba	Ni	Cu	Mn	V
Exposed vs. Reference	0.76 *** (0.4 to 1.1)	0.31 * (0.05 to 0.6)	0.22 ** (0.06 to 0.4)	0.2 * (0.06 to 0.4)	1.08 * (0.2 to 2.0)
Residential proximity to busy roads	−0.13 (−0.5 to 0.2)	−0.18 (−0.4 to 0.05)	0.09 (−0.03 to 0.2)	−0.1 (−0.3 to 0.01)	−0.1 (−0.8 to 0.5)
Orthodontic treatments	−0.87 * (−1.6 to −0.2)	−0.08 (−0.5 to 0.3)	0.3 * (0.04 to 0.5)	−0.05 (−0.3 to 0.2)	0.8 (−0.1 to 1.7)
Outdoor sports	0.13 (−0.2 to 0.5)	0.08 (−0.2 to 0.3)	0.006 (−0.1 to 0.2)	0.1 (−0.03 to 0.3)	−0.3 (−1.0 to 0.4)
Hobbies involving chemicals	0.08 (−0.2 to 0.4)	−0.07 (−0.3 to 0.2)	−0.1 (−0.3 to 0.006)	0.06 (−0.09 to 0.2)	−0.2 (−0.9 to 0.5)
Passive smoke	0.8 * (0.3 to 1.4)	0.36 (−0.07 to 0.8)	0.09 (−0.2 to 0.4)	0.2 (−0.2 to 0.5)	1.0 (−0.2 to 2.2)
Consumption of locally grown vegetables	0.1 (−0.06 to 0.3)	0.04 (−0.08 to 0.2)	−0.008 (−0.08 to 0.07)	0.09 (0.01 to 0.2)	0.005 (−0.4 to 0.4)
Constant	0.05 (−0.1 to 0.2)	−0.2 (−0.5 to −0.1)	−0.59 (−0.7 to −0.5)	−0.5 (−0.6 to −0.4)	−0.04 (−0.6 to 0.5)

Legend: only significant results (metal concentration) are presented. Metal concentrations were log-transformed to meet the normal assumption. Results (β coefficients and 95% confidence intervals) have been adjusted for covariates and consider the left-censored data present in metals distribution. * $p < 0.05$, ** $p < 0.02$, *** $p < 0.001$.

Considering the whole group of subjects, the Spearman's correlation matrix showed that Ba, Mn, Ni, and Cu (but not V) were correlated with each other, suggesting the possibility of a common source of emission (Table 3).

Table 3. Spearman's correlation matrix considering the toenail concentrations of Ba, Mn, Ni, Cu, and V in the whole group of enrolled children (n = 220).

	Ba	Mn	Ni	Cu	V
Ba	-	0.45	0.36	0.23	0.13
	-	***<0.000001***	***<0.000001***	***0.0006***	*0.059*
Mn	0.45	-	0.36	0.37	0.09
	<0.000001	-	***<0.000001***	***<0.000001***	*0.17*
Ni	0.36	0.36	-	0.23	0.09
	<0.000001	***<0.000001***	-	***0.0006***	*0.18*
Cu	0.23	0.37	0.23	-	0.02
	0.0006	***<0.000001***	***0.0006***	-	*0.82*
V	0.13	0.09	0.09	0.02	-
	0.059	*0.16*	*0.18*	*0.82*	-

Legend: data are Spearman correlation coefficients (rho, normal text) and *p*-values (in italic). Significant *p*-values are marked in bold.

4. Discussion

Results from the present study show for the first time an increased body burden of specific metals in children free-living in an urban area and exposed to emissions from waste incinerators, as compared with controls.

We used toenails as a biomarker of exposure to metals. Metals bind keratin proteins maintaining a stable concentration over time, independently from changes in metabolic activities [38,39]. The slow rate of growth of toenails (on average 1.62 mm/month) [37] allows to evaluate longer term exposure [37], as compared with blood or urine [38–40]. Few studies evaluated the correlation between the concentration of metals in nails and in other biological matrices, with variable results [40] probably due to the different time windows that can be explored using nails (6–12 months earlier [37,40,67,71,72]), blood (2–3 h [73]), and urine (3–4 days [74]). Positive correlations have been documented between concentration in toenails, urine, and blood in the case of Mn [75] which, in the present study, has been found in higher concentration in exposed children than in controls. Of note, positive correlations have been demonstrated between the concentrations of metals in toenails and in environmental matrices such as dust [61,71,76,77], soil [61,63,77,78], and water [63,79], confirming the adequacy of toenail as a biomarker of environmental exposure.

In exposed subjects, we found metals that, conversely, were in all cases below the LOD (As, Co, and Th) or were present in significantly lower concentrations (in particular Ba, Mn, Cu, and V) in children living in the reference area. Living within a 3 km circle from waste incinerators was a significant predictor of Ba, Ni, Cu, Mn, and V concentrations, after adjusting for covariates. The presence, in our study, of a correlation between the concentrations of these metals (with the exception of V) points to a probable common source of exposure. A recent health-risk assessment study indicated that ambient air around 3 km from a municipal waste incinerator had more PM1, PM2.5, and PM10 particles than general nonpolluted air [28]. The cited study also showed high noncarcinogenic risk and lifetime carcinogenic risk for children, derived from incinerator-emitted particle-bound toxic metals [28].

Our results are in line with a previous study determining air pollutants collected downwind from an Italian incinerator and showing that Mn, Cu, Ba, and V were among metals with the highest concentrations in both the fine and coarse fractions of the particulate matter [1]. In a study assessing the short-term oxidative potential of urban particulate matter in adult nonsmoking volunteers, several metals present in coarse, fine, and ultrafine PM (including Ba, Cu, Ni, and V) were significantly associated with increased levels of biomarkers of systemic inflammation, oxidative stress, and neural function. Ba, in particular, induced a significant increment (+11% at 1 h, +14% at 21 h postexposure) of L1(UCHL1) (traumatic brain injury marker ubiquitin C-terminal hydrolase L1); Cu exposure increased (+14% at 1 h) levels of the DNA oxidation marker 8-hydroxy-deoxy-guanosine; urinary cortisol increased by 88% after exposure to V, and the blood inflammatory marker VEGF (vascular endothelia growth factor) increased by 5.3% 1 h after Ni exposure [80].

Toenail concentration of Mn has been frequently studied both in children [47–50] and in adults [40], with an LOD ranging from 0.001 [81] to 0.33 μg/g [66] and values usually below 10 μg/g [40]. The highest Mn toenail concentrations have been found in subjects living near a highly industrialized city in Pakistan (average value 52.1 μg/g) [82] and in highly polluted areas in Cambodia (average concentration 43.9 μg/g) [66]. In our study, the average Mn concentration recorded in toenails from exposed children (4.4 μg/g) was slightly higher than that previously reported in pediatric age (3.57 μg/g, weighted means) in an analysis of pooled literature [47].

In Brazilian children aged 11–16 years and living in an urban area, fingernail metal concentrations are linked with the degree of urbanization (i.e., population density) and with the extent of vehicular traffic. This explains about half (50.8%) of the variance in metal concentration. In the cited study, the average Mn nail concentration measured in subjects living in the area with the highest population density was 1.3 μg/g, a value about 3.3 times lower than the mean Mn concentration detected in our series of exposed children [48]. This difference could be due, at least in part, to the coexisting exposure in our series of exposed children to vehicular traffic and industrial pollution. In fact, the average Mn nail concentration measured in our study in children living in the reference area (2.47 μg/g) and mainly exposed to vehicular traffic was close to that reported in Brazilian children.

According to a previous observation, urinary concentrations of Mn are inversely related to the distance of residence from a municipal solid waste incinerator, and are directly linked with the exposure

to particulate matter [31]. Mn was present at the highest level among heavy metals in particulate matter collected downwind of an Italian incinerator [1]. Mn has also been described as the metal with the highest concentration in soil [2,83] and with the second highest concentration in air (following Cu [83] or Pb [28]) around a solid waste incinerator.

Inhaled Mn can cross the blood–brain barrier and can enter the brain through axonal transport from the olfactory bulb to the cerebral cortex [84]. Children might be particularly at risk from Mn inhalation. In children aged 7–9 years living in East Liverpool (Ohio), a site with a hazardous waste incinerator and a manganese processor, a link has been shown between blood/hair Mn levels and neurological effects (altered IQ score) after adjusting for potential confounders [3].

In our series of enrolled children, the average Mn concentration in toenails from exposed subjects (4.4 μg/g) was 3 times higher than that measured (1.43 μg/g) in toenails from 225 school-age children (7–12 years) living in a Brazilian industrial region. In this group of subjects, a relationship has been demonstrated between high toenail Mn concentrations and the increased risk of intellectual deficit linked to Pb exposure, although the exposure was low (only 1.8% of children were above the CDC reference value of 5 μg/dL) [49]. A study assessing Mn accumulation in children aged 7–12 years and living near a ferro-manganese alloy plant indicated toenail Mn as a biomarker of environmental exposure, associating the burden of this metal in exposed subjects with disrupting neurobehavior. Of note, in exposed children, the median Mn toenail concentration recorded in the cited study was about 5 times lower than the mean value (0.84 μg/g) observed in our study [50].

Studies exploring the specific concentrations of heavy metals in air samples collected around a Spanish municipal solid waste incinerator showed that the highest concentration was registered for Cu [83,85]. Previous studies assessed nail Cu concentrations both in adults [40,86] and in children [47], indicating an LOD ranging, for this metal, from 0.009 to 0.12 μg/g, with values usually below 10 μg/g [40]. The highest Cu concentration in nails (average value 26.2 μg/g) has been recorded in subjects living in rural areas near a highly industrialized city in Pakistan [82]. The average Cu toenail concentration recorded in our series of exposed children (6.34 μg/g) was slightly higher than that (5.66 μg/g) measured in nails from Arab-American children living in a highly industrialized US area [47].

An increased Cu body burden has been related with increased oxidative stress secondary to the reduction of antioxidant enzyme activity and the generation of reactive oxygen species (ROS). These events are able to promote DNA damage, favoring the onset of cancer [87]. A recent study compared metal concentrations in nails from adults with non-Hodgkin or Hodgkin lymphoma, showing higher Cu levels in both groups of patients as compared with healthy controls. In the cited study, the mean nail Cu concentration in controls (4.8 μg/g) was very similar to that observed in our series of children living in the control area (4.74 μg/g), and Cu concentrations in nail samples from lymphoma patients (7.36 and 7.76 μg/g in non-Hodgkin and Hodgkin lymphoma, respectively) were only slightly higher that the average Cu concentration recorded, in our study, in exposed children (6.34 μg/g) [86].

Of note, children's exposure to Cu has also been linked with nononcologic conditions such as neurologic disorders [23–25] and obesity [22]. Significantly higher blood Cu concentrations have been found in obese children, as compared with healthy controls [88,89]. Additionally, a large cross-sectional survey on US children and adolescents demonstrated a strong association between the highest quartile of blood Cu concentration and obesity [22].

Ba is not essential in human nutrition, but, as mainly suggested by animal studies, health effects secondary to chronic Ba exposure are possible in humans, although results from epidemiologic studies are still scarce [90], as are biomonitoring reports [91]. The main routes of nonoccupational human exposure to Ba are the ingestion of contaminated food and/or water [90]. However, this metal is also frequently detected in particulate matter produced by several industrial combustion processes, including waste incineration [1,90].

In a group of 126 healthy Brazilian children living in an urban area (Porto Alegre) [51], mean Ba concentration in nails (5.6 μg/g) was 2.6-fold higher than that observed, in our study, in children living in the control area (2.15 μg/g), but 2-fold lower than that recorded in our exposed children (11.9 μg/g).

The average concentration of Ba observed in toenails from our series of exposed children was also about 9 times higher than the average Ba nail concentration measured in Arab-American children living in a highly industrialized US area (1.28 μg/g) [47] and 3.7 times higher than that reported in a series of 145 adults (3.21 μg/g), in whom a significant association between Ba levels in toenails and hearing loss at 8 kHz and 12 kHz was demonstrated after adjustment for sex, age, body mass index, and smoking [92].

Recently, Ba exposure during pregnancy (assessed by measuring Ba concentrations in maternal hair and in fetal placenta) has been dose-dependently linked with the risk of congenital heart defects in offspring, underlying health hazards deriving from prenatal and transplacental exposure to this metal [93]. Furthermore, data from the National Health and Nutrition Examination Survey (NHANES 1999-2011) found, in a large cohort of US children aged 6–19 years, a strong association between Ba exposure (urinary Ba concentration) and obesity [21].

Several studies measured the concentration of V in nails [40,47,48,81,94,95], reporting an LOD of 0.001 μg/g [81], an inverse relation with age [47,94,95], and values generally lower than 1 μg/g [40]. This was also the case of toenail V concentration measured in the exposed children from our study (0.19 μg/g). This concentration, however, was higher (about double) than that recorded in nails from Arab-American children living in a highly industrialized US area (0.09 μg/g) [47], in a series of Brazilian children living in an urban area (0.08 μg/g) [48], and as compared with the average concentration (0.11 μg/g) derived from pooled literature values in pediatric age [47].

In the present study, toenail concentration of V was higher in children living in the exposed area than in those in the control area. However, there was no relationship between toenail concentration of V and concentrations of Ba, Mn, Ni, and Cu that, conversely, were correlated with each other. This result could be due to a local source of anthropogenic emission of V different from the two incinerator plants. On the other hand, it is also possible that the same plants generate V, but through combustion processes not involving solid waste. In fact, air concentrations of V have been used as an indicator of emissions from oil combustion [96–98], and it has been suggested that burning waste oil in incinerators or using oil for providing power in incinerator plants can generate V emissions [98]. Vanadium has been measured in air samples around a Spanish incinerator [85], and a cross-sectional study assessing metal concentrations in spot urine samples from subjects living within 4 km from an Italian incinerator showed, in exposed subjects, V levels higher than the reference value for the Italian population [32].

According to our results, living in the exposed area was a significant predictor of toenail Ni concentrations, which were related with toenail concentrations of Ba, Mn, and Cu. Data also showed a trend towards an increased toenail concentration of Ni in children living in the exposed area compared to those in the control area.

Ni has been detected in both air and soil samples collected around a Spanish municipal solid waste incinerator [85], and a study in Taiwan showed that the burden of this metal in the local airborne particles was highly influenced by the stack emission of the local incinerator [4]. Additionally, a study analyzing samples of particulate matter collected in proximity of a Chinese municipal solid waste incinerator described fine particles as dominant, as compared with coarse and ultrafine particles, and anthropogenic metal elements (including Ni, Cu, V) predominantly concentrated in fine particles [5].

The average toenail concentration of Ni measured, in our study, in exposed children (2.23 μg/g), was slightly higher than that (1.8 μg/g) found in Brazilian children living in an urban area with high population density [48], but much lower than the mean concentration detected in Arab-American children living in an urban setting in a highly industrialized area (45.18 μg/g) [47].

In children, the exposure to Ni in particulate matter is negatively associated with indices of lung function. Ni vehiculated by PM10, in particular, has been linked with decrements in forced expiratory volume in the first second [99] and, according to data from school children living in an e-waste recycling area, the accumulation of Ni in serum could generate oxidative damage and decreased pulmonary function [19]. A recent study determining the concentrations of Ni in hair of pregnant women and in fetal placental tissues demonstrated a possible effect of Ni exposure in increasing the occurrence of

congenital heart defects in offspring [100]. Finally, Ni is a IARC Group 1 carcinogen, and a possible relationship has been suggested between urinary Ni levels and childhood acute leukemia, secondary to oxidative DNA damage [101].

A recent report showed increased blood levels of heavy metals (Cr, Pb, Cd), DNA damage and epigenetic changes (altered DNA methylation) in school age children living within 3 km around a Chinese waste incinerator [41]. This study confirmed previous evidence reporting higher Pb and Cd concentrations in blood samples from adolescents living near a Belgian incinerator than in controls [42]. Unfortunately, however, in both these reports, information on body levels of other metals are lacking.

In our series, children living in exposed or in control area showed similar toenail concentrations of Cd, Cr, and Pb. However, the proportion of subjects with concentration of these metals below the LOD tended to be higher in the control area. Our results are in line with two previous works reporting, in adults, no associations between living near a municipal solid waste incinerator and blood Pb and Cd levels [34,35]. Conversely, higher blood concentrations of Cr and Pb have been reported in adults living close to Chinese waste incinerators than in controls, with vegetable ingestion being the main contributor to the total average daily dose of these metals, as compared with Mn [33].

Thus, the possibility exists that site-specific exposure pathways (mainly dependent on dietary habits in rural areas) could influence the internal metal levels in exposed subjects, with consumption of local vegetables grown near incinerators being at risk for specific (i.e., Cr, Pb) body metal accumulation. In fact, in our series of enrolled children (all living in an urban area), consumption of locally grown vegetables was scarce and not linked with metal concentration. In this case, inhalation, rather than ingestion, could be the main exposure route.

In the present study, analysis of covariates suggested a possible influencing effect of previous orthodontic treatments and passive smoke on nail concentration of Ba (both factors) and Cu (only passive smoke). However, the role of these confounders seems to be limited, since living in the exposed area was a significant predictor of Ba, Ni, Cu, Mn, and V nail concentrations after adjusting for all considered covariates. Furthermore, no difference was evident in the distribution of subjects with previous orthodontic treatments and/or passive smoke in the two groups of explored children.

A previous longitudinal study based on dispersion modeling for exposure assessment explored health outcomes in a large cohort of subjects living in the same area examined in our study (3.5 km around the two incinerators of Forlì). Results showed significant associations between increasing heavy metal exposure and cause-specific mortality: colon cancer in men; all cancer sites, stomach, colon, liver and breast cancer in women; and excess of soft tissue sarcoma in the two sexes combined [54]. These findings point to the existence of an increased health risk in the same urban area in which results from our study have shown a greater internal accumulation of metals in exposed children, as compared with those living in the reference area.

Metals should be considered an indicator of exposure to a complex combination of pollutants generated from waste combustion, including gaseous pollutants, persistent organic pollutants, and a number of other toxic chemicals vehiculated by particulate matter. From this point of view, it should be underlined that cumulative exposure to complex mixtures of chemicals of industrial origin may generate synergistic effects on health [102]. Moreover, possible interactions between multiple and heterogeneous exposures (i.e., industrial pollution, vehicular traffic, contaminated water/food), should overcome the single-pollutant approach with the measurement of the absorbed internal dose of multiple pollutants (the exposome [103]).

Finally, some metals are characterized by a linear dose-response with low-dose effects and no threshold (i.e., Cu, Cd) or by a nonlinear dose-response with low-dose effects (i.e., Ni) [104]. These aspects also generate concern if metals are released in the environment at low concentrations.

Taken together, all these aspects amplify the possibility of health risk in pediatric age, also considering that children are more vulnerable to environmental toxins and have significantly more time, as compared with adults, for developing chronic effects of protracted environmental exposures, including both cancer and noncommunicable diseases.

5. Conclusions

The release of metals from waste incinerators located in an urban area can contribute to human toxicity following chronic exposure, in particular in children.

The present study employed the concentration of metals in toenails as an expression of long-term body accumulation of a wide panel of metals, demonstrating, in children living close to waste incinerators, an increased concentration of specific metals (in particular Ba, Mn, Cu, and V) potentially leading to an increased health risk.

Measuring the concentration of metals in toenails should be considered a noninvasive and adequate biomonitoring tool and an early warning indicator, which could allow a more realistic and comprehensive analysis of risk assessment as compared with the simple monitoring of environmental pollutants.

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Acknowledgements

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Contents

Executive Summary and Recommendations

The Dioxin, PCBs and Waste WG of IPEN report demonstrates that waste incineration residues represent a serious threat to both local and global environment as they contain high quantities of unintentionally produced persistent organic pollutants (U-POPs) listed under Annex C of the Stockholm Convention (dioxins, PCBs and hexachlorobenzene). This study also shows that especially waste incineration fly ash and APC residues contain also high levels of other POPs not listed under Stockholm Convention (for example polychlorinated naphthalens or polybrominated dibenzo-p-dioxins and dibenzofurans etc.). It summarizes studies showing leachability of dioxins from fly ashes under conditions they are disposed off. Hot spots case studies shows that levels of dioxins in ashes from waste incineration below the level established as a provisional limit for low POPs content in wastes are too high to prevent serious contamination of the environment by U-POPs.

Recommendations concerning crucial decisions on U-POPs policy

POPs levels in wastes:

Cases of dangerous contamination of the environment don't support approval of "low POPs content levels" and "levels of destruction and irreversible transformation" as they were proposed by the documents prepared within the framework of the Basel Convention.

Basel Convention Technical Guidelines and Stockholm Convention BAT/BEP Guidelines:

High levels of POPs in waste incineration residues raise the importance of using techniques other than waste incineration and/or landfilling of wastes in these guidelines. It also raises the importance of material substitution – the replacement of materials such as PVC, a material whose presence in the combustion processes helps to create more dioxins.

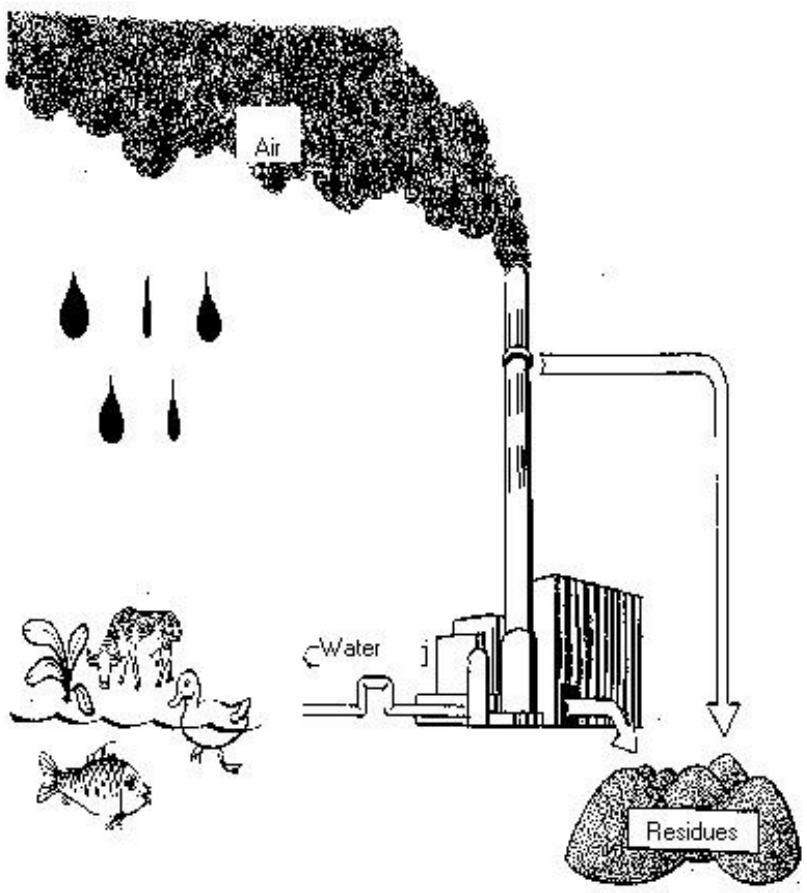
1. Introduction: Persistent organic pollutants (POPs)

Persistent organic pollutants (POPs) harm human health and the environment. POPs are produced and released to the environment predominantly as a result of human activity. They are long lasting and can travel great distances on air and water currents. Some POPs are produced for use as pesticides, some for use as industrial chemicals, and others as unwanted byproducts of combustion or chemical processes that take place in the presence of chlorine compounds.

Today, POPs are widely present as contaminants in the environment and food in all regions of the world. Humans everywhere carry a POPs body burden that contributes to disease and health problems. Dioxins, DDT or polychlorinated biphenyls (PCBs) are capable of causing hormonal defects in very low quantities and they threaten reproduction systems of people and animals. (They have for instance a negative impact on male fertility). They also damage the human immune system and some of them cause cancer. They are not soluble in water, but in lipids. This characteristic helps them bioaccumulate in the fatty tissue of animals.

The international community has responded to the POPs threat by adopting the Stockholm Convention in May 2001. The Convention entered into force in May 2004.

The Stockholm Convention is intended to protect human health and the environment by reducing and eliminating POPs, starting with an initial list of twelve of the most notorious, the "dirty dozen." Among this list of POPs there are four substances that are produced unintentionally (U-POPs): polychlorinated biphenyls (PCBs), hexachlorobenzene (HCB), polychlorinated dibenzo-p-dioxins (PCDDs)



Picture 1: Basic POPs releases flows from waste incinerator.

and dibenzofurans (PCDFs) The last two groups are simply known as dioxins.

The goal of the ***"continuing minimization and, where feasible, ultimate elimination"*** was established for U-POPs listed in Annex C of the Stockholm Convention.[a] There are several steps that should help Parties to Stockholm Convention to comply with this goal. Almost all are under Articles 5 and 6 of the Stockholm Convention.

Several key topics will be discussed at COP that reflect how the Convention will work:

1) **Guidelines on Best Available Techniques and Best Envi-ronmental Practices - BAT/BEP (related to Article 5 of the Stockholm Conven-tion),**

2) **Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases (related to Article 5 of the Stockholm Convention) and**

3) **"levels of destruction and irreversible transformation of POPs in waste" and "low POPs levels in waste" (related to Article 6 of the Stockholm Convention).**

These three topics are also very closely related to fly ash and other waste incineration residues and will be discussed in the final parts of this report.

Annex 1 to this report includes more detailed profiles of the group of U-POPs listed in Annex C of the Stockholm Convention.

[a] polychlorinated biphenyls (PCBs), hexachlorobenzene (HCB), polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs), last two groups are called simply as "dioxins"

2. POPs and waste incinerators

A wide range of POPs is produced in waste incinerators, as unwanted by-products of the combustion process. Therefore, the Stockholm Convention lists waste incinerators in Annex C among *"source categories have the potential for comparatively high formation and release of these chemicals[b] to the environment"*. The basic possibilities of releases of toxic substances from waste incinerators are demonstrated at Picture 1. The incinerators themselves are usually much more complicated devises, as shown by the diagram at Picture 2, and in any incinerator many ways can be identified through which POPs may get further into the environment. The amounts of dioxins and further POPs produced by a specific waste incinerator also differ, depending on the conditions of the incineration of wastes. A number of studies investigated formation of dioxins in incinerators.

Three pathways have been proposed so far to explain the formation of PCDDs/PCDFs during incineration:
- high temperature pyrosynthesis[1];
- low temperature de novo formation from macromolecular carbon and organic or inorganic chlorine present in the fly ash matrix[2], and
- formation from organic precursors[3] in which fly ash has an important role as a catalyst.

Although all these mechanisms have been known for many years, some detailed reaction mechanisms were studied in more recent studies due to the extreme complexity of the fly ash matrix.[4, 5]

Formation of further POPs during incineration of wastes was not examined in such detail as it was done in the case of dioxins. Some studies focusing on examination of coplanar PCBs, which are included into the value of the total TEQ[6], concluded that these chemicals might be formed by similar reactions as PCDD/Fs[7].

Similar imbalance exists concerning the attention paid to releases into the various components of the environment. Until now, the highest attention has been paid to releases into the air, whereas the content of POPs in wastes and waste waters has been left aside for a long time. A help in solving this problem should have been provided by the Stockholm Convention, which, in contrast to protocol on POPs to the LRTAP Convention, concentrates on releases into all components of the environment, and does not deal solely with releases into the air. In spite of that, the tool prepared by UNEP Chemicals for national inventories of POPs in many cases still ignores or underestimates releases to water, land and in residues, as will be shown in one of the following chapters.

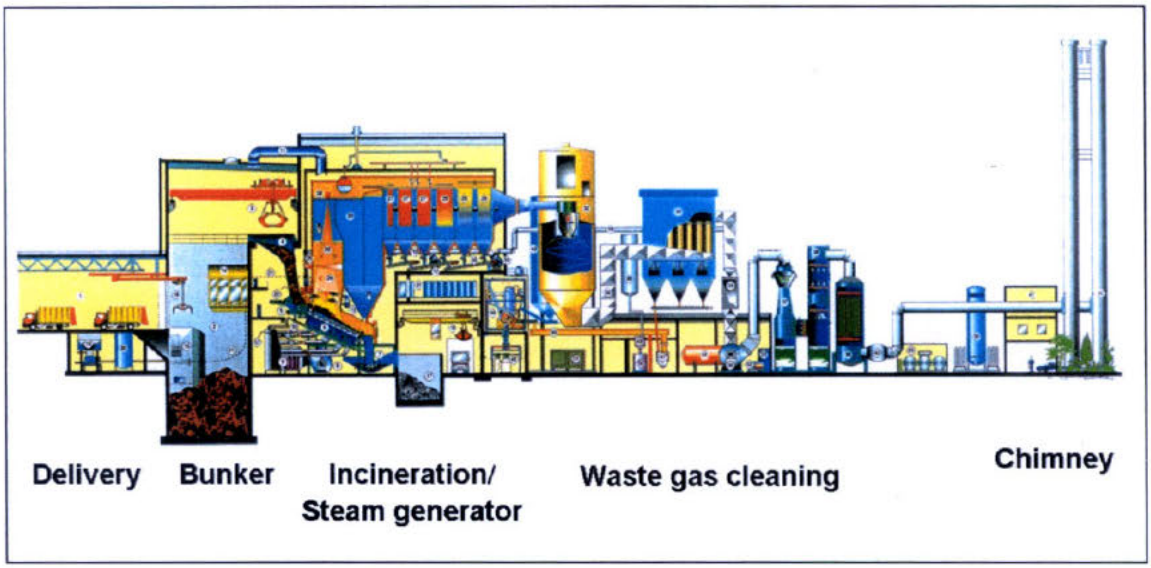
[b] Chemicals listed in Annex C of the Stockholm Convention, which are PCDD/Fs, PCBs and hexachlorobenzene so far.

3. Waste incineration residues

Combustion is a thermal process during which organic waste materials change their chemical composition and break down into basic atoms after being exposed to high temperatures in the presence of oxygen. The flue gases, as well as dust particles which are not captured by filters are emitted into the air by the stack (chimney). And, large quantities of waste water from wet flue gas filter devices as well as from fly ash treatment are discharged in the environment.

up in the bottom ash at the end of the incineration process. Approximately 25% of the quantity of municipal solid waste (MSW) fed to the grate furnaces ends up as bottom ash after the combustion process. Bottom ash is also known as "slag".

Fly ashes are small dust particles in flue gases, and are captured by electrostatic precipitators (ESP-filters) after the flue gases leave the boiler.



Picture 2. Typical municipal solid waste incinerator Source: European Commission 2004.

Inert materials in the solid waste stream, such as stony materials, and most metals, which are incinerated together with the organic waste fraction are not combustible, and will fall through the grate slits of the furnace, and end

Fly ashes are also known as 'ESP-ash'. Approximately 1 to 5 % of the quantity of municipal solid waste fed to the grate furnaces ends up as fly ash after the combustion process.[8]

Table 1: Modern incinerators produce a range of residues[c].

Generic Residue	Origin	Specific Residue
Bottom Ash / Slag	Heterogeneous material discharged from the burning grate of the incinerator.	Grate Ash
	Material that falls through the burning grate to be collected in hoppers below the furnace	Grate riddlings

[c] Adapted from WRc/ETSU Report. Reports on potential for use of MSWI bottom ash, for the DTI Ref B/RR/00368/REP/. Harwell, Oxford 1996

Heat Recovery Ash	Particulate ash removed from heat recovery systems	Boiler ash Economiser ash Superheater ash etc
Fly Ash	Particulate matter removed from the flue gas stream prior to the air pollution control (APC) system, not including the heat recovery ashes	Electrostatic precipitator (ESP) dust Cylcone dust
APC (Air Pollution Control) Residues	Dry and semi dry scrubber systems involving the injection of an alkaline powder or slurry to remove acid gases and particulates and flue gas condensation/reaction products. Fabric filters in bag houses may be used downstream of the scrubber system to remove the fine particulates	Scrubber residue Bag house filter dust
Combined Ash	Combination of any of the above residues, most common is mixing of bottom ash with APC residues.	Mixed ash

A third residue of waste incineration is boiler ash. Small ash particles attach to the boiler, and are removed by mechanical knocking devices, or are manually removed during periods of maintenance work. Less than 0,1% of the quantity of municipal solid waste fed to the grate furnaces is collected as boiler ash.

If an incinerator is equipped with (wet) flue gas filter devices (scrubbers), various (solid) residues are produced, i.e. scrubber salts, filter cake, sludge, and gypsum.

Summarizing: After incineration approximately 26 - 40 % of combusted solid waste will remain as solid residues. Quantification of residues will be discussed more detailed in Chapter 4.

Combustion of liquid (toxic) waste results in much lower quantities of solid residues, because of the lower amount of solid substances in the liquid waste.

What types of wastes are produced can be understood also from the three following examples of incinerators operated in the Czech Republic:

SPOVO Ostrava. Industrial wastes incinerator SPOVO in Ostrava is the only incinerator in the Czech Republic which holds a license to incinerate wastes with high content of PCBs. Data about the incinerator are taken from its operating rules. The technology consists of a combustion chamber - rotary kiln, electrostatic filter, acidic and alkaline gas washer, hose filter and of the technology for capturing of nitrogen oxides (so-called DENOx).

The incinerator produces the following wastes:
- slag and boiler ash from the rotary kiln (cat. No. 190111)
- fly ash, captured by the electrostatic filter (cat. No. 190113)
- sludge with the content of heavy metals from the filter press located after treatment of waters from the acidic gas washer (cat. No. 190105)
- gypsum from the alkaline washer (cat. No. 190105)
- used activated carbon from the bag filter (cat. No. 190110)
- wastes formed during repairs of lining (cat. No. 190111)

The incinerator with the capacity of 10.000 tons per year consumes 1.134 tons of calcium hydroxide and 140 tons of activated carbon and transforms them into hazardous waste. The contaminated activated carbon is incinerated in the incinerator itself.

Medical waste incinerator in the Hospital of Rudolph and Stephanie in Benešov u Prahy.
This incinerator is an example of a small facility with a capacity of 1000 tons per year. Data thereon are taken from the plan for reduction of emissions, because the technology does not meet all requirements arising from transposition of European regulations concerning waste incinerators. Its equipment should be completed by the end of the year 2004.

The technology consists of pyrolysis and combustion chamber, textile bag filter for capturing solid particles and simple two-stage treatment of flue gases. This treatment consists of quench (cooling of flue gases by water), and of alkaline lye washer.

The incinerator produces the following wastes:
- *waste from pyrolysis (cat. No. 190118)*
- *boiler ash (cat. No. 190104)*
- *solid waste from APC devices (cat. No. 190107)*
- *waste waters are discharged by the incinerator into the sewer system without treatment*

The facility was built in the year 2000. In spite of that, the limit for emissions of dioxins was not met. In the year 2001, the limit of 0.1 ngTEQ/m^3 was exceeded ca 19x, in the year 2002 even 65x.

Hazardous waste incinerator in Lysá nad Labem. This incinerator has the maximum capacity of 3500 tons per year. Data thereon are taken from the plan for reduction of emissions and from the operating rules. At present, also the EIA process for completion of its waste management equipment is under way. The incineration space consists of a rotary kiln and two post-combustion chambers. Treatment of flue gases has several stages. At first, the flue gases are cooled, then a sorbent (a mixture of lime and activated carbon, trade name Sorbalite) is added thereto. Subsequently, the mixture is introduced into a reactor, where flue gases and sorbalite are mixed with each other. From the flue gases, solid portions (fly ash and sorbalite) are filtered off in a textile bag filter. Finally, the flue gases enter quench and alkaline washer, where they are washed with water and lye. Wash waters from the washer are further treated in a filter press and by filtration through CINIS ash.

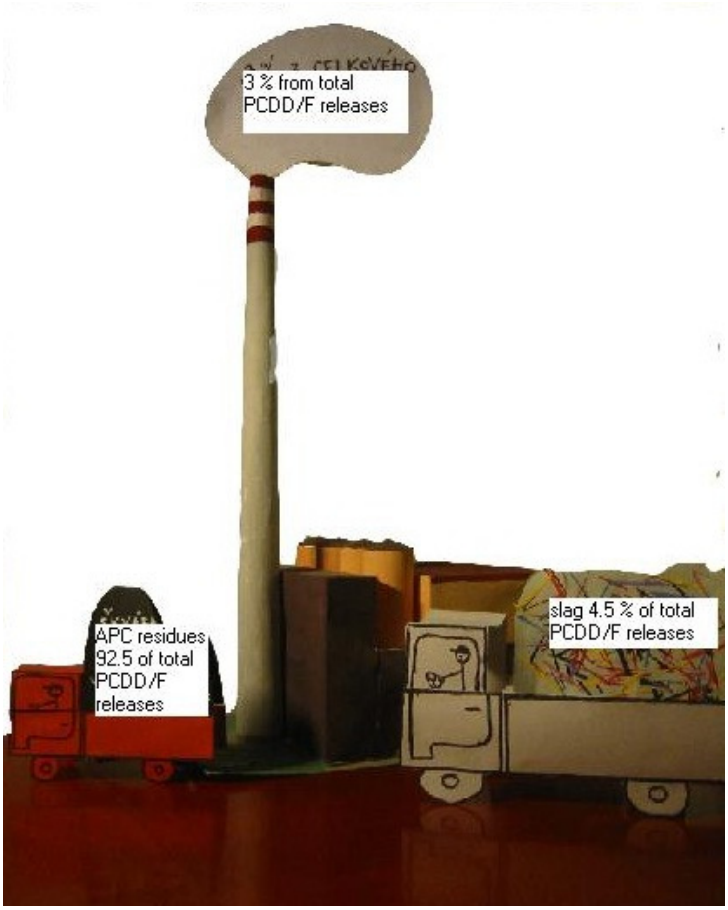
The incinerator produces the following wastes:
- *ash and slag and fly ash from the post-combustion chambers (cat. No. 190111, 190113)*
- *mixture of sorbalite and fly ash from the sleeve filter (cat. No. 190107)*
- *sludge with the content of heavy metals from the filter press located after treatment of waters from the gas washer, it is re-burnt (cat. No. 190105)*

The incinerator with the capacity of 3500 tons per year consumes 40 tons of sorbalite and 2 tons of CINIS ash (it is part of sludge from the filter press). Wastes, produced during repair works, are not specified.

Physical properties of ash residue fractions may be affected by such factors as:
- MSW composition;
- front-end processing of the waste prior to incineration;
- facility design and operation including combustion temperature;
- air pollution control (APC) measures etc.[9]

Higher content of dioxins and further POPs in wastes produced by incinerators may be, naturally, expected in air pollution control residues (APCR). Their content in slag and ash is increased by mixing with fly ash or with boiler ash. But this is a relatively frequent practice, as will be shown on several examples. Boiler ash contains higher concentrations of POPs, which, however, by far do not reach the concentrations found in APCR. On the other hand, ash and slag may contain relatively high concentrations of heavy metals.

P. Littaru and L. Vargiu studied process of dioxins formation in fly ash in two municipal waste incinerators in Italy[10]. They concluded that "*The highest PCDD/F contents have been found in fly ash at temperatures of 150-200 °C below the de novo synthesis peak temperature, so that the enrichment of particulates in PCDD/Fs must be caused by adsorption from gas to solid phase. PCDD/F ratios in fly ash tend to increase with decreasing temperatures until reaching values well in excess of 1.7, the average furan/dioxin ratio for MSWI emissions, revealing that a major portion of PCDF is adsorbed on the solid phase… These phenomena of adsorption/desorption on fly ash deposits in flue gas treatment lines must be accounted for in the mass balance and in the evaluation of PCDD/F emission levels…… PCDD/Fs appear to be generated on fly ash deposits in flue gas treatment lines of MSWIs by the de novo synthesis mechanism. PCDD/F content in fly ash increases as temperatures in the treatment lines decrease, confirming previous findings about temperature as the major controlling parameter in PCDD/F formation.*"



Picture 3: Balance of PCDD/Fs releases into different environment compartments from MWI Liberec

The Italian study confirmed that combustion is not the main source of PCDD/Fs in MSWIs, and that PCDD/Fs do not seem to be generated directly only by waste combustion. Based on its findings the effectiveness of post-combustor units in destroying PCDD/Fs needs to be reconsidered. This conclusion is supported by findings of the M. Chang and J. Lin who studied influence of activated carbon injection on total dioxins releases[11]. They came to the conclusion that activated carbon injection can indeed effectively decrease concentrations of dioxins in gas, but it increases the total emissions of dioxins (including dioxins in fly ash and gas) from municipal waste incinerators.

Similarly as in waste incinerators, POPs are formed also in other combustion facilities. Therefore, also wastes produced, for example, by metallurgical plants, present serious risk of contamination of the environment by POPs. Use of slag from metallurgical plants caused one of „dioxins scandals" in Germany[12].

4. How much dioxins do the wastes from incinerators contain?

An important question, which has to be answered when we speak about wastes produced by incinerators, is: How much dioxins do these wastes contain? The magnitude of problems connected with these wastes depends on the answer to this question. If the amount was negligibly small, then it would not be necessary to be further concerned with the problems of these wastes. Answers to this question are different.

For example, Dyke and Foal[13] identified MSW incinerator residues as the largest dioxin release to land in the U.K., noting as follows: *"Residues from the incineration of MSW can lead to significant releases."*

Table 2: Results of the analysis of combustion gases and ashes from the incineration of medical waste in Poland.

Incinerator	PCDDs/PCDFs in pulverulent gases [ngTEQ/Nm^3]	PCDDs/PCDFs in gas phase [ngTEQ/Nm^3]	Temperature of combustion gases [°C]	PCDDs/PCDFs in ash [µgTEQ/kg]	Incineration temperature [°C]
1	0.015	0.010	60	8.5	650 - 750
2	0.02	0.012	80	14.5	780 - 850
3	0.022	0.020	45	20.0	670 - 900
4	0.027	0.020	55	7.8	750 -1000
5	0.047	0.040	75	12.1	500-600
6	0.055	0.040	40	12.5	650 - 850
7	0.075	0.050	90	15.0	550 - 780
8	0.09	0.075	105	22.0	600-700
9	0.13	0.12	65	19.0	575 - 800
10	0.215	0.215	140	29.0	550 - 700
11	0.32	0.085	40	9.5	780 - 900
12	0.42	0.15	60	19.5	550 - 700
13	3.9	2.5	120	9.0	650 - 800
14	9.7	4.2	80	18.4	600-650
15	12.1	8.5	200	22.5	580 - 650
16	18.5	11.5	170	43.0	750 - 900
17	26.0	24.2	270	35.0	600-700
18	32.0	21.5	250	30.0	500 - 850

Source: Grochowalski, A. 2000.[14]

Sakai and Hiraoka[15] determined the total dioxin output per metric ton of municipal solid waste (MSW) incinerated when fly ash was treated by a thermal dechlorination process. However, their findings also allow calculation of the total dioxin output per ton MSW when fly ash is not detoxified, as is typically the case in most countries. With untreated fly ash, a dioxin output factor of 857.8 µg TEQ/ton MSW can be calculated for one set of samples and 507.7 µg TEQ/ton MSW for the other. In the first case, flue gas contributes 0.05 percent of the total TEQ output while fly ash contributes 99.9 percent. In the second case, flue gas contributes 0.0004 percent of the total TEQ output and fly ash, 99.5 percent. These values can be compared to a study of European MSW incinerators by Huang and Beukens[16] in which flue gas was found to contribute 11.8

percent of total dioxin output, while fly ash contributed about 56.7 percent.

We have tried to calculate this balance roughly also for municipal waste incinerator in Liberec (see Chapter 8.2.1). We can say for sure that gaseous emissions contribute ca 3 % to the total dioxins production of this incinerator. The remaining 97 % are present in mixed bottom ash. In this case, it is complicated to estimate the exact contribution of APC residues.

But it is possible to roughly estimate the contribution of dioxins contained in the separated slag, which is ca 4.5 %. This would mean that APC residues contribute ca 92.5 %. Similar calculation for dioxin-like PCBs is not available, as PCBs are not commonly measured even in air releases.

Fly ashes and further residues from flue gases treatment form the highest proportion of dioxins releases to the environment: between 56 and 99.5 %. Usually, gaseous emissions contribute to dioxins burden from waste incinerators by the lowest per cent (this can be estimated between 0.0004 and 12 %). Releases of dioxins contained in fly ashes represent a serious threat to the environment. Therefore, it is important to determine *„low POPs level"* for the content in wastes according to Article 6 of the Stockholm Convention, in order to prevent releases of these toxic substances into the environment. Success of the Stockholm Convention in elimination of POPs can be based on correct setting of this limit. As shown by the case studies in Chapter 8., *„low POPs levels"*, as they were approved and adopted at the sixth Conference of Parties (COP6) of the Basel Convention, 25–29 October 2004, do not guarantee protection of the environment from POPs contamination.

Talking about dioxins and dioxin-like PCBs observed in ashes we find a wide range of measured levels. For PCDD/Fs we found in previous studies observed levels between 36 ng I-TEQ/kg dry matter[17] to 82,400 ng I-TEQ/kg d.m.[18] Boiler ash contains lower levels of dioxins (level of 11.3 ng I-TEQ/kg was measured in Liberec).[19] Mixed bottom ash can carry high levels of dioxins (up to 2300 ng I-TEQ/kg d.m.[20]), while bottom ash and/or slag doesn't have such high levels: 0.64 - 150 ng I-TEQ/kg d.m. were observed in municipal waste incinerators in England and Wales.[21] We did not find a lot of data about dioxin-like PCBs in fly ash, only from Taiwan where measurements with results ranging from 61.1 to 2,983.4 ng I-TEQ/kg,[22] were recorded, and from Germany with levels found in the range of between 10 - 640 ng WHO-TEQ/kg. Also PCBs in general are seldom measured in waste incineration residues. In fly ash their levels were measured from less than 1,000 to 23,000 ng/g d.m. in UK[23]. Table 2 shows PCDD/Fs levels measured in flue gases and ashes of Polish medical waste incinerators.

5. Leaching question of POPs in fly ash

After emissions of dioxins into the atmosphere were successfully lowered in the up-to-date incinerators, the idea has predominated that these toxic substances are fixed in fly ash to the extent that it is essentially unnecessary to pay too high attention to management of wastes produced by the incinerators. During negotiations on permits for waste incinerators, this argument is often stated in official documents, and it is passed on among officials who issue the corresponding permits. Authorities in a significant number of countries thus do not pay any attention to the facts where APC residues end and how they are treated. The authorities are satisfied with submission of a certificate confirming that the incinerator handed over the material to an authorized company. They are satisfied with the same statement also in documentation submitted during procedures of permit granting in (= Environmental Impact Assessment) or IPPC (= Integrated Pollution Prevention Control) processes.

The idea of a complete impossibility of leaching of toxic substances from slag, ash, and APC residues is based on a number of studies which have worked, and repeatedly work, at leachability of heavy metals from these materials.

The leachability tests performed recently may not be applied to substances of dioxin type, because their behavior changes depending on the changes of the characteristics of the environment. The leachability tests of wastes performed commercially are, in most cases, generally carried out in ideal laboratory conditions and do not correspond to the behavior of wastes in the environment where they are deposited. Therefore, the chemists themselves call for change of these procedures. For example, M. Podhola from Institute of Chemical Technology, Prague in his study of stabilized wastes stated: *„A specifically prepared leachability test may be considered more suitable. Such test should stimulate conditions of subsequent deposition of the waste, if these conditions are known. Obviously, it is not possible to carry out these tests exclusively in the commercial manner. Apparently, they will have to be carried out in cooperation with research establishments.“*[24]

Older studies on behavior of dioxins in soils supported the original idea of strong fixing of dioxins in fly ash and ash. Italian study from 1986 reported that the Seveso soil profiles did not show a significant translocation of the PCDD/F in the soil environment.[25] German study from 1992 showed that only a little movement was found within 8 years in the surroundings of two industrial plants in southwest Germany and there was no appreciable loss of PCDD/F.[26] Another German study asserted that only highly chlorinated congeners were detected in the solution obtained from leaching experiments following the method of the German DIN 38414 test etc.[27]

However, newer studies disprove the idea of strong fixing of dioxins in fly ash and ash or slag. Takeshita and Akimoto[28] proposed the leachability of PCDD/F from fly ash by rain using a fly ash column. They showed that PCDD/F associated with water-soluble salts such as NaCl and $CaCl_2$ in the ash were eluted in the beginning of the elution, whereas those associated with slightly water-soluble particles such as calcium hydroxide were eluted in the latter half. Another report from 1995 focused on leaching of dioxins from fly ash and soils under fire-extinguishing water activity suggested that fire-extinguishing water use resulted in significant amounts of PCDD/F in the leachate.[29]

Korean scientists Yong-Jin Kim, Dong-Hoon Lee a Masahiro Osako studied PCDD/Fs leachability under circumstances comparable to those in landfills theoretically and in laboratory conditions. In theoretical review, it was shown that dissolved humic matters (DHM) could influence the actual solubility and leachability of PCDD/F. The higher concentration of DHM showed the higher leachability of PCDD/F. In the leaching test, three different DHM concentrations and pHs of solutions were adopted to fly ash samples imaging the various characteristics of municipal solid waste leachate. It was proved experimentally that the leachability of PCDD/F increased with increasing DHM concentration in all pH conditions. The highest leachability was shown at the highest pH. Isomer distribution patterns of PCDD/F in all leachates were similar.[30]

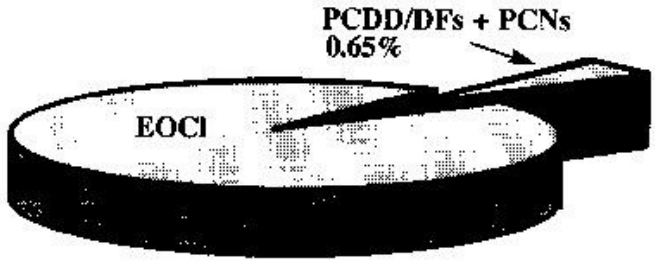
A previous study of these scientists states that a mixture of bottom ash and fly ash shows a higher leachability of dioxins.[31] This leads to the opinion that DHM are formed due to the presence of non-combusted carbon in bottom ash. The results also show several shortcomings in procedures of waste testing, because dioxins behave differently than heavy metals. Because of that, the authors of the study propose to rethink certain methods of testing.[32]

Sakai, Urano and Takatsuki published another study focused on leaching of dioxins and PCBs from fly ash. Leaching tests with and without surfactants were conducted in order to understand the influence of surfactant-like substances on POPs leaching. In those tests, LAS (Linear Alkylbenzene Sulfonate) and humic acid was used as surfactant-like substances. Shredder residues from car/electrical goods recycling and fly ash from a municipal solid waste (MSW) incinerator were used in content analyses and leaching tests. Furthermore, an experiment was carried out to understand the influence of fine particles to the leaching concentration of POPs. The results of the leaching tests indicate that surfactant-like substances increase the leaching concentration of POPs, and fine particles related closely to the transporting behavior of POPs.[33]

6. Other POPs observed in ashes

Waste incineration residues are formed by process of combustion of different kinds of wastes. They should contain plenty of chemicals as such. There will be difference in distribution of different chemicals between slag/bottom ash and fly ash/APC residues. It is necessary to say that if analysis for PCDD/Fs and/or PCBs content in ashes is rare, than analysis for other chemicals is very sporadic. There are several studies filling this gap a bit.

Picture 4. Distribution of PCDD/Fs and PCNs value comparing to rest of EOXs found in fly ash sample from one of Japanese municipal waste incinerators. Source M. Kawano et al.[39]



Japanese experts team led by M. Kawano studied distribution of PCDD/Fs, polychlorinated naphthalens (PCNs) and EOX in waste incineration ashes (fly ash and bottom ash). [34] PCNs have high chronic toxicity potential in animals[35] and exhibit the same binding affinity with the aryl hydrocarbon receptor (AhR) as non-ortho PCBs[36]. Kawano et al. found that order of content of these chemicals was EOX> PCDD/Fs>PCNs in the fly ash samples from MWI. Picture 4 shows balance between studied chemicals in one of fly ash samples. "The results of calculation show a very small amount of known organochlorines like PCDD/Fs and PCNs to have been present as a fraction of EOCI (see Picture 4). This is implies that a large part of EOCI is composed of unknown compounds." stated M. Kawano et al.

Noma et al. studied PCNs formation during Neoprene FB combustion in simulated MWI conditions and measured levels in fly ash as well as bottom ash in a range from 0.17 to 0.96 ng/g and from 0.95 to 1.7 ng/g respectively.[37]PCNs in ashes[d] sampled from Japanese incinerators ranged from 0.74 ng/g to 610 ng/g.[38]

In German study focused on a comparison between chemical analysis data and results from a cell culture bioassay was found that with MWI fly ash samples the bioassay of the extract resulted in a two- to fivefold higher estimate of TCDD equivalents (TEQ) than the chemical analysis of PCDDs/Fs and PCBs. However, the outcome of both methods was significantly correlated, making the bioassay useful as a rough estimate for the sum of potent PCDDs/Fs and dioxinlike PCBs in extracts from MWI fly ash samples. The remaining unexplained inducing potency in fly ash samples probably results from additional dioxinlike components including certain polyaromatic hydrocarbons (PAHs) not analyzed in this study. The hypothesis that emissions from MWI of hitherto unidentified dioxinlike compounds are higher by orders of magnitude than emissions of potent PCDDs/Fs and dioxinlike PCBs could not be confirmed.[40]

Levels of PAHs observed in waste incineration fly ashes by M. Till et al. ranged between 0.05 µg /g and 0.99 µg/g. Higher levels were found in fly ashes from cematorium, wood combustors and noble metal recycling facility (up to 536.4 µg/g).[41]

[d] both bottom and fly

H. R. Buser et al. conducted study focused on polychlorodibenzothiophenes (PCDTs), the sulfur analogues of the PCDFs. In H. R. Buser et al. study from 1991 is stated: *"Since incineration is one of the main sources for the environmental occurrence of PCDDs and PCDFs, the additional presence of PCDTs may have some implication , particularly because of the presence of 2,3,7,8-tetra-CDT."*[42] Tetra- and penta-CDTs were detected in fly ash from two MSWIs and from an electric-arc furnace of a car shredding facility. Rather complex isomeric profiles were found with tetra- and penta-CDTs predominating, at levels up to 25 and 30 ng/g.[43]

Picture 5: Surrounding of Turkish hazardous waste incinerator Izmit with sampling site of free range chicken eggs, which were found highly contaminated by PBDEs. Photo by: Bumerang and Greenpeace.

The toxicology of the PCDTs is not yet known but it can be supposed that like chlorinated dioxins and furans these compounds are biologically active.[44]

Also other organic compounds were observed in waste incineration residues from Izmit HWI. Some of them are listed in analytical results of chemical analysis of sampled ashes conducted by Greenpeace Research Laboratories.[45] See them in Appendix 2.

Burning of the waste containing brominated flame retardants quite often presented in the waste of plastic consumer products leads to formation of polybromodibenzodioxins and polybromodibenzofurans (PBDD/Fs) and/or to polybromochlorodibenzo-dioxins and polybromochlordibenzo-furans (PBCDD/Fs). Burning of polybrominated diphenylethers (PBDEs) in waste incinerators can lead to significant releases of this persistent organic pollutant, because they are not decomposed by waste incineration under low temperatures for example. High levels of these compound were found recently in chicken eggs sampled nearby HWI in Izmit (Turkey) at site on Picture 5.[46]

Chatkittikunwong & Creaser studied flyash from three municipal and medical waste incinerators for chlorinated as well brominated dioxins in 1994 for example. They found total PBDD/PBDF and polybromochloroDD/DF levels detected in MWI ranged between 2.3 to 3.5 ng/g and in medical waste incinerator 1.2 ng/g.[47]

It is clear that waste incineration residues contain whole range of organic pollutants and we can count many of them to the family of persistent organic pollutants. Some of them appear in ashes because of their presence in wastes (PBDEs for example) while the others can occur in ashes as POPs by-products. PCNs, PBDD/Fs , PCBDD/Fs and PCDTs are examples of second case. Some of these compounds were found in significant levels in the environment and waste incineration residues can be their significant source.

The pattern of toxicity of PCNs resembles that of TCDD. Recent work has been done to

determine the relative potency of PCNs - mixtures as well as individual congeners - in fish, birds and mammals. The potency of several PCN congeners is in the same range as some PCB congeners.[48] These findings about PCNs toxicity call for listing at least this group of chemicals under Annex C of the Stockholm Convention and for their inclusion into national POPs inventories.

7. Country case studies

7.1 Waste incineration residues in Netherlands

7.1.1 History of dioxins in Dutch milk

The Lickebaert polder is an agricultural area north-east of Rotterdam-harbour in the Netherlands. In 1989, tests showed high levels of dioxin in milk and cheese samples. As a result of the enormous media coverage and publicity, the Dutch government promptly ordered cow's milk and meat from the affected Lickebaert area to be collected systematically and destroyed.[49] A health protection measure that lasted until the end of 1994. During these five years the production and sales of dairy products in the Lickebaert area was prohibited. And, the government started a nationwide research program to get detailed information about dioxin contamination of cow's milk in other regions. For this purpose cow's milk was examined in the vicinity of all Dutch waste incinerators and cable burn facilities. [50]

The nationwide research program showed that dioxin output of all waste incinerators have been too high as well as dioxin levels of cow's milk. Further, the research program suggested that the high dioxin output from waste incinerators could be responsible for toxic dioxin contamination of cow's milk and meat. In February 1990, Dutch government ordered that cow's milk and meat from a second contaminated area (near the waste incinerator of the city of Zaanstad, north of Amsterdam) should be collected systematically for destruction. Further, the production and sales of dairy products in that 'Zaanstad-area' was prohibited. [51, 52]

As a result of the nationwide research program four municipal waste incinerators were ordered to close down immediatedly. And, in 1993 and 1994 two other municipal waste incinerators had to shut down. Surprisingly, the AVR-Rotterdam incinerator that was held responsible for the contamination of dairy products in the Lickebaert area received permission to continue its operation. The amount of waste incinerated dropped from about 2983 kilotons in 1990 to 2957 kilotons in 1995 (because of re-use and prevention and because of incineration capacity available, the incinerator of Roosendaal was out of business for renewal in 1995).[53]

Despite the serious concerns of citizens against waste incineration, the Dutch government continued their policy to triple the incineration capacity in 2000.[54, 55] However, strong citizens protests forced government to drop a few new incinerator proposals, and to close down another existing incinerator. Although citizens protest have been successful in preventing the building of a few new incinerators, others have been build. And, despite the fact, that the government was not successful in increasing the incineration capacity as initially planned, waste incineration has become a major route for waste disposal in the Netherlands.

We try to show the problems related to handling waste incineration residues in developed European country in this case study. This case study and data in it are based on study conducted for IPEN Dioxins, PCBs and Waste WG. [56]

7.1.2 Waste incineration residues in Netherlands: introduction to the real issue

The Netherlands incinerates roughly 38% of its municipal waste yet has relatively high rates of recycling of municipal waste at approximately 25%.[57, 58] In 1999 a total of 6,965 ktonnes of

waste (excluding contaminated soil, dredging spoil and manure) was incinerated.[59] The Netherlands have the largest installations in Europe for municipal waste incineration with a medium capacity of 460 kt/a.[60] In 2000 there were 11 MWI in operation in the Netherlands.

In 1995, the Dutch government issued a directive with environmental specifications for construction materials, which include all materials that are used for building houses, offices, factories and roads.[61] Although waste incineration fly ash and bottom ash should come to meet the limits (like all other construction materials and residues), the government decided that fly ash and bottom ash are exempt from this obligation. As a result, fly ash and bottom ash can be used almost without any restriction.[62] Looking at levels of different chemicals in waste incineration residues from Netherlands showed in Table 3 this is not a good practice for protection of environment.

7.1.3 Fly ash

The annual production of fly ash is ranging from 79000 - 81000 tons in the Netherlands. The fly ash production is quite steady because the quantity of incinerated waste has not been changed for the past few years. The annual production of boiler ash has decreased from 8800 tons in 1999 to 3800 tons in 2002.[63]

Approximately 35000 - 40000 tons of annual fly ash production is used as filler material for asphalt production. However, since fly ash is produced during the year, but asphalt is manufactured mainly during summer, and other filler materials compete with fly ash, not all fly ash can be disposed of as filler material in asphalt.[64, 65] During the life time of asphalt toxic substances can be dispersed into the environment, as a result of leachate. To our knowledge no study was carried out on this topic.

Table 3. Average composition of fly ash and bottom ash from Dutch waste incinerators in 1997 (in milligrams per kilogramme). For bottom ash numbers of analyzed samples were not available.[a, a, a, a]

Substance	Average levels in fly ash (mg/kg)	Number of samples analyzed	Average levels in bottom ash (mg/kg)
aluminium (Al)	30,294	17	not defined [b)]
arsenic (As)	97	17	19 - 23
cadmium (Cd)	379	17	2 - 8
chromium (Cr)	231	31[a)]	235 - 296
copper (Cu)	1,154	17	669 - 3212
mercury (Hg)	2	17	0,03 - 0,2
lead (Pb)	7,671	17	1086 - 1637
molybden (Mo)	50	17	5 - 11
nickel (Ni)	88	30[a)]	40 - 86
selenium (Se)	9	17	0,4 - 0,5
strontium (Sr)	245	17	not defined [b)]
tin (Sn)	1,007	17	62 - 77
vanadium (V)	30	27[a)]	40 - 52
wolfram (W)	77	17	not defined [b)]
zinc (Zn)	22,488	17	1239 - 2125
bromine (Br)	997	17	not defined [b)]
chlorine (Cl)	74,471	17	1050 - 2445
fluor (F)	57	17	not defined [b)]
dioxins (PCDD) and furans (PCDF)	0.0024 (in I-TEQ)	17	below detection limit

[a)] between 1986-1995
[b)] Not defined = no measurement carried out

Approximately 44000 - 46000 tons of annual fly ash production is landfilled in the Netherlands, or exported to Germany and dumped in old salt and coal mines. [66] In 2002, 29500 tons were exported, in 2003, 45000 tons. Most of the boiler ash is exported to Germany as well.[67, 68]

For the landfill disposal route, the fly ash is packed in so called large plastic bags and piled up in separate sections of common landfill sites. To stabilize the big bags, sand is squirted, or washed between the bags to fill the hollow spaces. Alternatively, a fly ash mixture is used as top cover for common landfill sites.

After the big bags are piled up in the separate sections of the landfill site, the water that is used to squirt, or wash the sand between the bags get into contact with the fly ash, accellerating the leachate process. Moreover, heavy pressure exerted on the landfill can make big bags burst, increasing the leachate process any further. Also the fly ash mixture that is used as top cover for common landfill sites can rupture after heavy pressure exerted on the lower layers of the landfill will increase tension in the top cover. As a result, rain water easily get in contact with the waste landfilled below the cover layer, reinforcing the process any further.[e]

7.1.4 Bottom ash

In the Netherlands, the annual production of bottom ash is approximately 1.200.000 tons. The bottom ash production is quite steady because the quantity of incinerated waste has not been changed for the past few years.

In 2002, 770.000 tons were used for road beddings, and hardening surfaces of industrial sites. This is much lower compared to previous years, when 820.000 up to 1.340.000 tons have been dumped under roads. Waste incinerators have storage facilities for periods during which road building activity is lower. However, the drop in 2002 is not a result of a small demand for road works, but because of growing concern about the negative environmental impact of dumping bottom ash under roads. Road constructors have been increasingly reluctant to further use bottom ash for road construction. In consequence of this growing concern, the quantities in stock at incinerators have increased to 1.028.000 tons by the end of 2002, which is almost as much as annual production.[69]
Small quantities of bottom ash are landfilled on common landfill sites and exported respectively. In the past few years the annual quantities landfilled ranged from 700 to 12.500 tons. In 2002 and 2003 3,200 and 2,300 tons of bottom ash respectively were exported.

Similar with fly ash, the use of bottom ash as a bedding for roads brings the ash easily into contact with other (non hazardous) materials used for road construction, like sand and stones. But, inevitable, roads need to be reconstructed, or repaired, and the old road debris that need to be removed contains elevated levels of toxic substances. Mixture of bottom ashes, fly ashes and other materials can increase leachability of dioxins from these materials as dissolved humic matters content increases. [70]

7.1.5 Inventories of dioxins in fly ash and bottom ash

In the Netherlands, fly ash is a major route for dioxin releases from waste incineration to the environment. In 1991, the National Institute of Public Health and Environmental Protection (Dutch EPA) estimated the quantity of dioxins in fly ash and bottom ash for 1020 g I-TEQ/year and 8.5 g I-TEQ/year respectively. Since 1991, the incineration capacity has been increased from 2760 kilotons to 5200 kilotons in 2000. For 2000 the quantity of dioxins in ash is estimated 2671[f] g I-TEQ/year.[71, 72]

Compared to fly ash, which is the main carrier for dioxins in residues from waste incineration, dispersion of dioxins in the environment by bottom ash was considered to be small. Heavy metals in bottom ash pose a much bigger burden for the environment.

[e] for more information about leaching fly ash ability look at Chapter 5

[f] this figure includes dioxins in bottom ash and filter residues.

According to information from the operators of the Dutch waste incinerators in 1997 [73], and based on annual production of fly ash, annual dioxin quantity in ashes is estimated 190 - 195 g I-TEQ. These figures differ strongly from the official estimates from Dutch EPA, and University of Amsterdam.

7.1.6 Conclusion

The disposal of fly ash and bottom ash, in asphalt, road beddings, landfill sites and salt and coal mines contributes to an increased dispersion of hazardous substances in the environment, some of them, like dioxins, classified as persistent organic pollutants (POPs). It is not surprisingly that with this on-going annual burden, the background levels of dioxins in the Netherlands remain high, and, according to the Health Council of the Netherlands, the recommended (health protecting) levels for humans and in some cases for ecosystems are being exceeded. [74]

7.2 Other EU Member States

Economic expenditures connected with management of residues produced by incinerators differ in the individual EU Member States, depending on differing practice in the individual countries, and also depending on differing conditions (including economic ones). These differences are shown in Table 4. The following two Chapters summarize information on legislation concerning management of waste incineration residues in two EU Member States, Austria and Sweden, information concerning this issue in both the United Kingdom and the Czech Republic are present in Chapter 8 „Hot spots case studies".

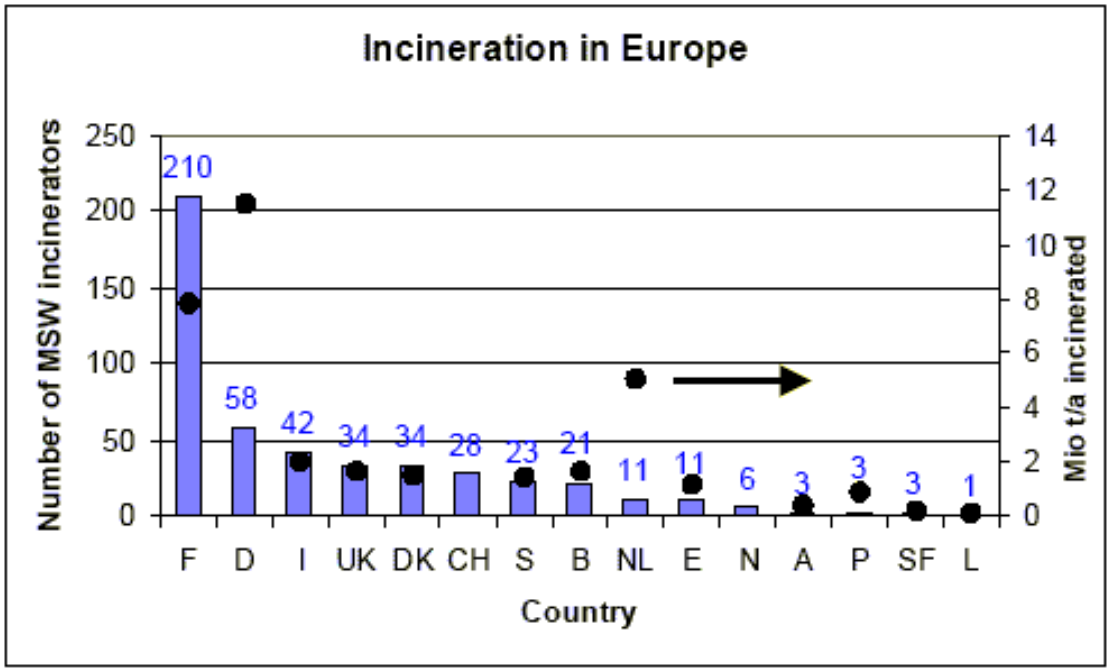
Table 4: Costs of operators of municipal waste incinerators connected with treatment of bottom ash and wastes resulting from flues gases treatment in EU countries. Source: Eunomia 2001.[a]

Country	Bottom ash, slag EURO/t	APC residues EURO/t	Note
Austria	63	363	-
Denmark	34	134	-
Germany	28.1	255.6	including fly ashes
Italy	75	129	including fly ashes
Luxembourg	16	8	-
United Kingdom	used as construction material	90	-

7.2.1 Austria

In Austria, management of wastes produced by incinerators is regulated by two directives, namely by the Directive on Waste Incineration, and by the Directive on Landfilling. The first of these Directives[75] requires facilities incinerating and co-incinerating wastes to minimise the amount and harmfulness of wastes produced by them, and to carry out analyses thereof (determining the amount of harmful substances both in the wastes and in the leachate from the wastes). Documents concerning the analyses must be kept for one year, at least, and must be given at disposal to authorities. In the case that the limit for dioxins (100 ng I-TEQ/kg) in the wastes is exceeded, then the wastes must be treated in order to reduce this value below the limit. Further, according to the Directive, formation and dispersion of dust from these wastes must be prevented during transport and intermediate storage.

According to a communication from the Austrian Ministry of the Environment, dated May 2004, filter cake from treatment of gases, and a part of fly ash, are handed over to Germany. The second part of fly ash, as well as bottom ash, are landfilled, or solidified and then landfilled. Activated carbon from flue gases treatment is incinerated. Gypsum from wet flue gas washers is landfilled, solidified and then landfilled, or used as a construction material.[76]



Picture 6: Number of municipal waste incinerators and amount of incinerated municipal waste in European countries in 2000. Source: UBA 2002.[a]

7.2.2 Sweden

In 1999, 22 incinerators were in operation in Sweden. They incinerated, in total, 1.9 million tons of waste. This amount included 1.3 million tons of municipal waste and 100 thousand tons of waste wood. The remainder was formed by hazardous (industrial) waste. In the same year, the incinerators produced 370.000 tons of bottom ash which contained 5 to 10 I-TEQ PCDD/Fs. Further, ca 50 thousand tons of wastes from flues gases treatment were produced by the incinerators. These wastes contained, in average, 2 to 3 ng/g PCDD/Fs. In 1999, all Swedish incinerators released 3 g I-TEQ PCDD/Fs into the atmosphere (in 1985, this was 90 g Eadon TEQ PCDD/Fs). The amount of dioxins (PCDD/Fs) in wastes from flue gases treatment was many times higher: 110 - 120 g I-TEQ.

According to results of analyses of wastes from flue gases treatment produced by 6 Swedish incinerators, carried out in 2002, the average concentration of dioxins in the wastes was 0.2 ng I-TEQ/g (median being 0.22 ng I-TEQ/g).[77]

7.3 Pakistan - medical waste incineration

Medical waste incineration is quite a common treatment for medical wastes in Pakistan. Medical waste is burned in small scale waste incinerators without any air pollution control devices (APC) and/or with a very simple one.[78] The residual ash is buried at general dump sites like this near Charsadda road (near Peshawar) which this study focuses on and/or in deep holes with very poor or no insulation to prevent the leaching (leaking) of toxic substances from the ashes into underground water resources (for example in Shifa Internationals Hospital, Islamabad or in SK Cancer Hospital, Lahore - see photos at Pictures 7 - 11).

A small scale waste incinerator located in LRD Hospital, Peshawar (Pictures 7 and 8) contributes to the quantity of residual ash dumped at the Charsadda road dump site, where this ash was observed to be a potential

source of dioxin contamination in free range chicken eggs collected from near village. [79]

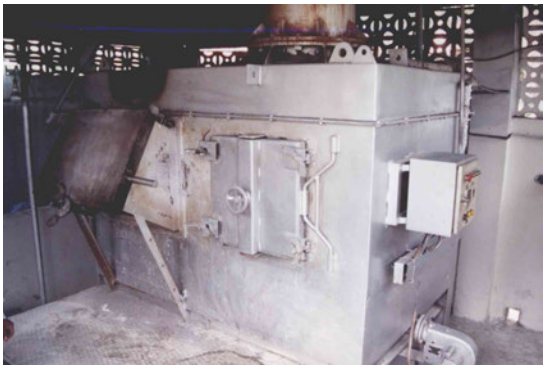
The LRD Hospital incinerator is one of 4 located within the North Western Frontier Province. It was built using the Chinese company Minama technology with two chambers without any air pollution control equipment (APC). It burns selected infectious waste from the hospital and runs for 4 - 8 hours per day with the exception of Sunday when it does not work at all. This is common in almost all other medical waste incinerators in Pakistan resulting in many start up and cool down operations occurring during the week. The LRD Hospital waste incinerator was built in 2001 and is already obsolete. It burns about 250 kg of infectious waste per day. These are figures for small scale medical waste incinirators using one kiln.

There are non-combustion alternatives to waste incineration which can avoid U-POPs releases as required by one of major aims of the Stockholm Convention. In Tabba Heart Institute, Karachi there is already a suitable alternative to an incinerator installed, an autoclave. Findings of this study support this method of dealing with medical wastes as a solution that makes Stockholm Convention aims achievable.

Situation in Pakistan gives representative picture of more developing countries (in India and/or Kenya).

Pictures 7 and 8: Medical waste incinerator in LRD Hospital, Peshawar. Small scale medical waste incinerator, typical for Pakistani hospitals. Photo by: Jindrich Petrlik.

Pictures 9 - 11: Waste incineration residue in the deep hole - storage built in the area of hospital. Cover of similar hole in another hospital. Double chamber kiln in one of Pakistani medical waste incinerators. Photos by: Jindrich Petrlik



8. Hot spots case studies

8.1 Hot spots and incineration residues in United Kingdom

There are currently 17 municipal waste incinerators in the UK[g], of which Edmonton is the biggest. Thirty-three new ones were under construction or in various stages of planning at the beginning of 2001[80]. The Byker Combined Heat and Power waste incinerator located in the city of Newcastle upon Tyne burnt refuse-derived fuel (RDF).

Since 1998, waste companies in UK have been using less hazardous 'bottom ash' collected in incinerator grates and selling it to be mixed with asphalt or concrete and used in building projects.

The operators of both Byker and Edmonton incinerators had been illegally mixing this bottom ash with the more toxic fly ash from the air pollution control devices (APC).

The scandal surrounding the dumping of toxic incinerator ash on Newcastle upon Tyne allotments and footpaths in 2001 revealed that incinerator operators across Britain may have been breaking the law while avoiding the cost of disposing of toxic ash in special hazardous waste landfills by selling it to be "recycled" into building projects.

Amazingly while the UK's Environment Agency was gathering evidence to procecute the operators of the Byker incinerator for spreading a mixture of fly and bottom ash in areas around Newcastle upon Tyne, it had full knowledge that the operators of the Edmonton

[g] 2 in Scotland, 1 in Jersey, 1in Wales and rest is located in England. About two-thirds of incineration capacity in England was according to study carried out by Environment Agency in 2002 concentrated around London and the West Midlands.

Table 5: PCDD/F levels in ash, soil and eggs in allotments with poultry in I-TEQ in pg/g (source Pless-Mulloli et al.[a])

Allotment name	Ash	Soil 30cm	150cm**	Eggs No.	Type	Fat basis	Distance from ash in m
• Allotments, which have received incinerator ash							
Blaney Row	150	7	N/A	3	H	4.4	0,20
				1	H	0.8	0
				1	H	8.9	20
Branxton A	3000	95	49	3	H	25	0
				3	B	56	0
Branxton B	3000	272	90	3	H	17.5	10,15
Brunswick	373	11	N/A	3	H	7	20
Coxlodge	4224	27	28**	3	H	1.5	30
Denton Dene	1636	34	N/A	2*	H	25	0,0
Hulne Terrace	910	14	N/A	3	H	31	0,10,20
				1	H	29	0
				1	H	0.4	10
				1	H	3.6	20
St. Anthony's	20	23	25**	2*	H	27	0,20
				2	D	9	0,0
Westmacott Street	2123	45	20	3	H	18	0,0,30
				1	H	5.6	0
				1	H	19.4	0
				1	H	2.9	30
Controls							
Hawthorn Farm	na	-	-	3	H	0.2	na
Pets Corner***	na	-	-	3	H	20	na

Notes to Table 4: H= Hen, B= Bantam, D= Duck, *one egg broken in transport, **samples from Environment Agency (EA) analysis program, sampling was done in parallel to this study, but strategy for analysis was to include all 30cm and 150cm samples, na=150cm samples only analyzed if 30cm sample above 40pg/g I-TEQ, ***The egg sample at Pets Corner was taken as control, but turned out to have contamination with PCDD/F. This was due to overflows of a stream contaminated with sewage sludge.

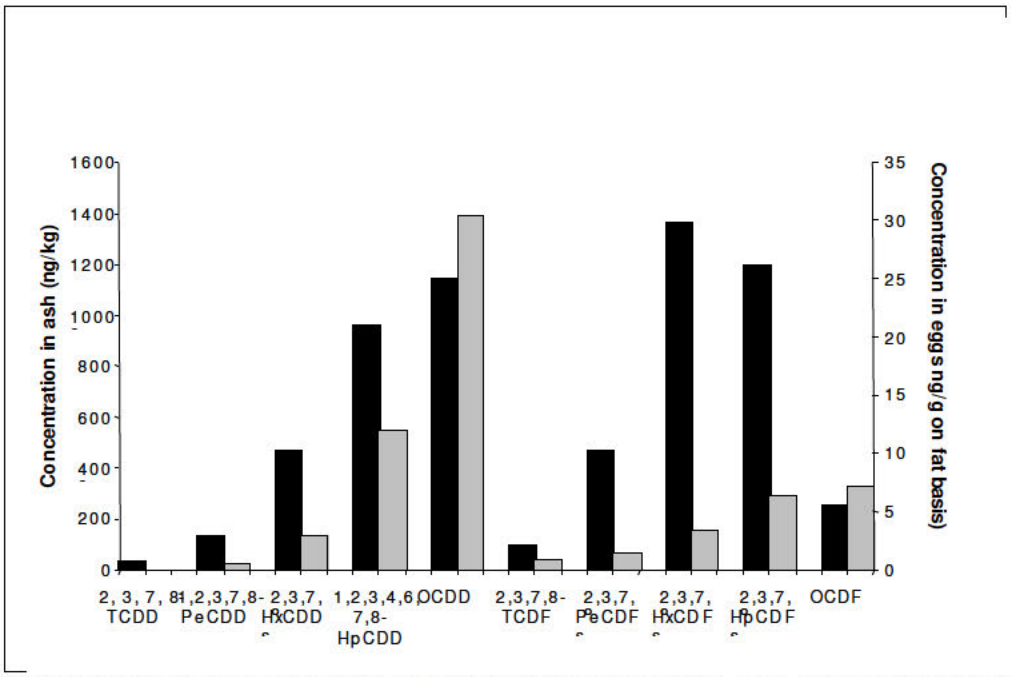
incinerator in North London had been mixing fly and bottom ash for 30 years (until August 2000) and was simultaneously sitting on a working Ash Group with the operators encouraging the use of similar mixed ash as road aggregate, breeze block type building bricks, and hard core in car parks.[81]

In December 2001, air pollution control residues leaked during unloading at the Castle Environmental plant due to a fault in the pipework. The dust was damped down after instructions from the Agency.

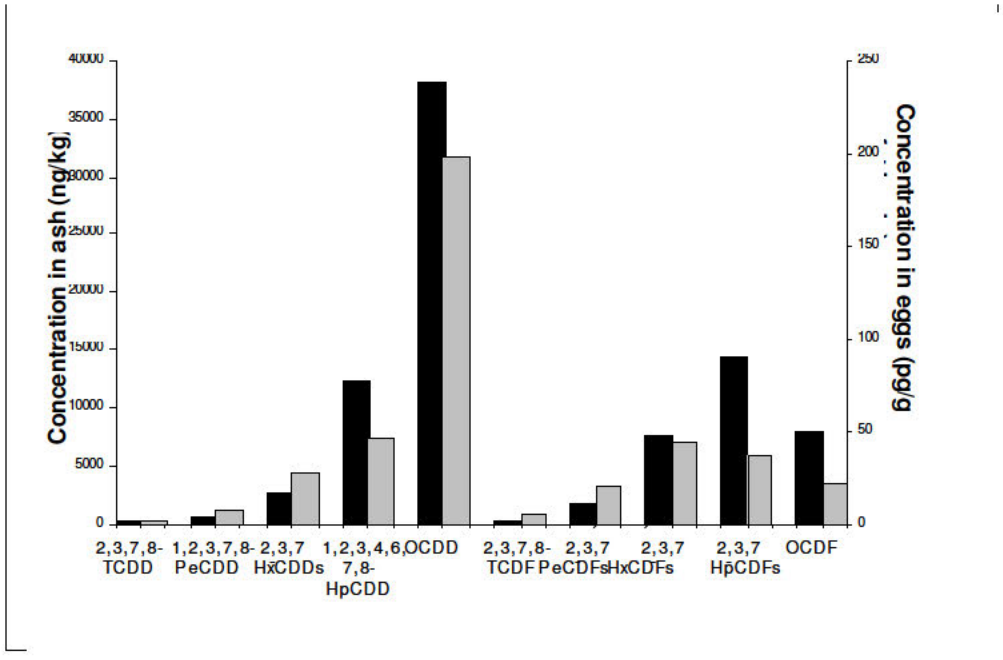
The plant installed for mixing wastes and powders were provided, in 4 cases, with suitable extraction and dust abatement equipment; in the other plant, no extraction was installed, but other dust suppression procedures were used. One plant had been the subject of occasional dust complaints from members of the public.

8.1.1 Newcastle

In the years 1994 - 1999, an estimated 2000 tons[82] of fly ash and bottom ash from the Byker incinerator were spread on food producing land, farms, flower beds, school playing fields, bridal pathways and footpaths around Newcastle. Tanja Pless-Mulloli et al.[83] of Newcastle University studied the influence



Picture 13: Coxlodge: ash 4,224 ng/kg I-TEQ incinerator pattern, eggs 1.5 pg/g I-TEQ lipid basis non-incinerator pattern, chicken do not have access to ash



Picture 12: Westmacott Street: ash 2123ng/kg I-TEQ, incinerator pattern, eggs 18pg/g I-TEQ lipid basis, incinerator pattern, chicken have access to ash

of its use on contamination of soil and poultry. They examined a number of factors that could influence the level of dioxins contamination. The results of their study are summarized in Table 5. Concentrations of dioxins found in the mixed ash ranged from 0.02 to 9500 ng/kg d. m. (in I-TEQ).

Seventeen out of 19 egg samples from allotments which had received ash showed levels of of its use on contamination well in excess of barn held supermarket eggs. 17 out of 19 egg samples from

allotments, which had received incinerator ash showed influence of ash in the pattern of contamination (see Picture 12). The weighted average of all egg samples was 16.4pg/g I-TEQ. The weighted average for those samples, which showed the incinerator pattern in the egg samples was 22.2pg/g I-TEQ.

Wastes showing dioxins concentrations 750 - 3.5-times lower than "low POPs level" for dioxins[84] set out by the Basel Convention, used in Newcastle for reconstruction of footpaths, have resulted in contamination of poultry eggs which on average, exceeded 5.5 to 7-times the limit for the content of dioxins in eggs set out later in the European Union.

8.1.2 Edmonton

The operators of Edmonton MWI were supplying mixed ash to construction block manufacturers and to replace aggregate for road construction and car parks knowing full well it contained as much as 3,600ng/kg to 10,800ng/kg of dioxins. Therefore the level of dioxin contamination in this fine mixed ash would be in excess of 1100ng/kg, significantly higher than the 200ng/kg, (peaking at 900ng/kg) left as a result of spraying Agent Orange in Vietnam, where they are still reporting birth defects and elevated dioxin levels in human tissues 30 years after the spraying ceased. [85]
Typically, the mixed ash was mixed with 1 – 3% cement, 25 – 50% furnace bottom ash, for example from a power station, 25% aggregates and water. The amount of mixed ash in a typical block varied from about 10% to 25%. Blocks containing mixed ash from two different manufacturers have been identified, sampled and analysed for dioxins.

There is evidence of fly ash from Edmonton as high as 10,800ng/kg I-TEQ and calculations showing the final levels of dioxin in mixed ash as being 771ng/kg I-TEQ. Further tests on dioxins in fly ash from UK plants were in the region of 6,600 and 31,000ng/kg[86].

Results of four analyses show a range 117 – 390 ng ITEQ/kg of dioxins in the blocks. Tests conducted by the BBC documentary programe *Newsnight* 7 on a sample block made from 30% of Edmonton ash showed 343ng/kg. [87] By contrast, blocks incorporating Edmonton bottom ash with no electrostatic precipitator ash, would be expected to contain less than 4ng ITEQ/kg. Table 6 shows the dioxin concentrations found in a range of construction blocks and bricks in Edmonton

Table 6: Dioxin concentrations in construction materials

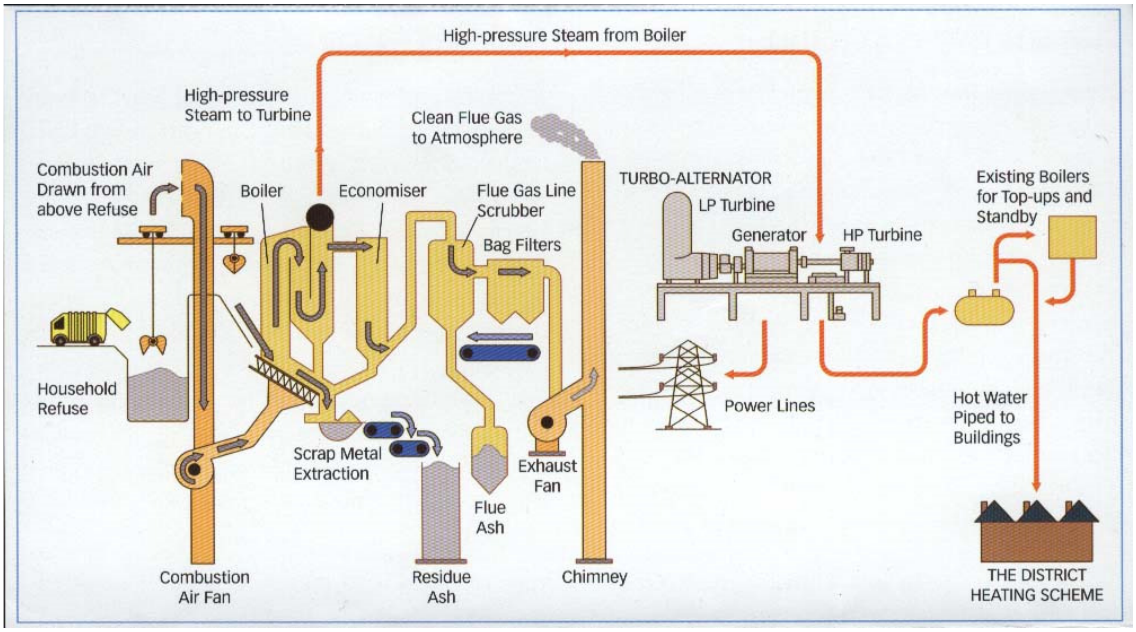
Construction blocks	ng ITEQ/kg	Bricks	ng ITEQ/kg
Thermalite	1.5	Chesterton	1.4
Hem PQ/7a	3	Leicester	1.7
Lignicite	1	Fletton	0.9
GGBS Ash	1	Other	
Celcon	2	Ordinary Portland Cement	0.5 to 1
Stock Brothers. Breeze	12	Pfa ex Ratcliffe	6.7
Durox	10	Pfa ex Drax	2.8
blocks from Edmonton mixed ash	117 to 390	blocks from Edmonton bottom ash	expected 4* measured 23**

Notes: * Calculated by EA report[88] authors. Based on the average dioxin concentration in Edmonton bottom ash of 10 ng/kg ITEQ[h].

** One block reported only to contain bottom ash from Edmonton was analysed and found to contain 23 ng/kg ITEQ dioxins.

[h] See Annex 18 in EA 2002: Solid Residues from Municipal Waste Incinerators in England and Wales. A report on an investigation by the Environment Agency, May 2002

Picture 14. Edmonton. Most current UK plants have a conventional grate, superheater, economiser, semi-dry scrubber with lime and activated carbon injection followed by a bag house as shown in the schematic below (with the generally optimistic addition, in this case, of the district heating system!). Edmonton is an unusual configuration because the acid gas removal plant and the new bag house were 'bolted onto' the existing electrostatic precipitator system.



8.2 Hot spots and incineration residues in the Czech Republic

Fly ash, bottom ash and other wastes from incinerators in the Czech Republic have been deposited in hazardous waste landfills for many years. In 1997 a decree of Law on wastes set a limit on the dioxin content in wastes of 10 ng/g. Wastes exceeding this limit would have to be stabilised and then deposited in a speacialised hazardous waste only landfill. Simultaneously with the introduction of this law, the fees for depositing wastes on hazardous waste landfills increased significantly.

The sum of these measures have resulted in the operators of waste incinerators looking for ways to avoid paying these high landfill fees for fly ashes and for the means to avoid measurements of dioxins in fly ashes. Due to the benevolence of the state authorities they have been successful in both these aims as documented by the case of the municipal waste incinerator in Liberec in further text.

Arnika Association in its previous report on waste incineration residues estimated amounts of dioxins content in produced waste incineration ashes in 2002. Municipal waste incinerators released 20 g I-TEQ of dioxins in residues. Estimation of dioxins level released in ashes from hazardous waste incinerators[i] in the Czech Republic ranged between 7.5 and 150 g I-TEQ. These calculations were based on the official figures about waste production in the Czech Republic for 2002 and the range of measured levels of dioxins in waste incineration residues.[89] Large range of measured levels of dioxins in fly ashes from hazardous waste incinerators (see Annex 2) is the reason for large range of dioxins produced by hazardous waste incinerators.

8.2.1 Liberec

The municipal waste incinerator in Liberec began operations in 1999. It is designed in such a way that fly ash is mixed with bottom ash. The incinerator, having a capacity of

[i] including medical waste incinerators too

Picture 15: Municipal solid waste landfill in Košťálov, where the mixed ashes from MWI in Liberec were dumped for long time without any pretreatment.
Photo by: Vítězslav Roušal.

96.000 tons of wastes per year, produces between 25 and 40 thousand tons of this ash mixture yearly[j]. Despite this mixture exceeding the limit for dioxin contamination as set out in the law[90], the incinerator was allowed to deposit the ashes on a municipal waste landfill in the year 2000.

The situation has changed since then as new law on wastes and a decree have cancelled the limit set for the content of dioxins in wastes. They have set out that fly ashes from waste incinerators must be, without any measurements, stabilised and then deposited on hazardous waste only landfills. Simultaneously, the operators of the Liberec incinerator, the company Termizo, obtained a certificate allowing the mixture of fly ash and bottom ash to be sold as a construction material.

The Ministry of the Environment of the Czech Republic set out orientation limits for the decontamination of old ecological burdens in 1996. There is no doubt that if sometime in the future the sites where the mixed ashes from the Liberec incinerator has been deposited are checked for the content of dioxins, they will most certainly exceed the limit B[k] set out by the binding methodical instruction of the Ministry. Exceeding limit B in soils is considered a serious pollution problem having a negative influence on human health and individual components of the environment and as such requires further measures being taken.

Increased levels of dioxins in eggs and meat of free-range poultry have been caused by concentrations of dioxins that were 10x (and sometimes even 100x) lower than this limit.

It is impossible at this moment in time to establish whether the described use of the mixture of ashes from the incinerator in Liberec has resulted in increased concentrations of dioxins in soils and animals because the location of the dumping sites is secret and known only to Termizo, the incinerator owner. These sites are unknown even to state authorities in charge of environmental supervision.

8.2.1.1 The case of the incinerator in Liberec, Guidelines on BAT/BEP and limits for the content of POPs in wastes

Concerning the treatment of residues from municipal waste incinerators, the "Guidelines on Best Available Techniques and Best Environmental Practices (BAT/BEP)", proposed to be adopted by COP 1 of the Stockholm Convention, state the following: *"Bottom and fly ash from the incinerator must be properly handled, transported and disposed*

[j] Specific amounts for years 2001 - 2003 are shown in Table 8.

[k] Limit B = 0.1 ng I-TEQ/g dry weight

of. Covered hauling and dedicated landfills are a common practice for managing these residues. Particularly if reuse of the residues is contemplated, an evaluation of the content and potential environmental mobility of chemicals listed in Annex C is required, and guidelines adopted by the Basel Convention and subsequently adopted by the Conference of the Parties of the Stockholm Convention should be followed. Periodic analysis of the ash can also serve as an indicator of incinerator performance or the introduction of illegal or unpermitted wastes or fuels (for example, the detection of high metal content in the ash as a result of burning construction debris in an incinerator permitted to burn only virgin wood).

Scrubber effluents, including the filter cake from wet flue gas cleaning, is regarded as hazardous waste in many countries and must be properly treated and disposed of. If the concentration of chemicals listed in Annex C or other toxic materials (for example, heavy metals) is sufficiently high, these materials may be consigned to landfilling as hazardous waste."

In the case of the Liberec incinerator, satisfying this text in practice will not result in any change to the better. It will continue to be able to use the mixture of bottom ash and fly ash as a construction material. Why? Because the "Guidelines on BAT and BEP" refer to the "*guidelines adopted by the Basel Convention"*. According to them, it is not necessary to treat the waste in any special way if it does not contain dioxins in concentrations higher than 15 µg I-TEQ/kg dry weight. Table 6 shows levels of dioxins found in wastes produced by the Liberec municipal waste incinerator. In the case of the adoption of the POP levels according to Basel Convention, the Stockholm Convention will fail to protect public health and the environment from releases of dioxins from fly ashes produced by the waste incinerator in Liberec.

The BAT principle is also used in the EC Directive about Integrated Pollution Prevention Control. In the case of the incinerator in Liberec, an operating license has been already issued according to this Directive[91]. Not only did the competent authority fail to prevent the mixing of fly ash and bottom ash, it failed to establish a duty to make measurements of hexachlorobenzene and PCBs in fly ash and other wastes produced by the incinerator.

8.2.1.2 Calculation of releases of PCDD/Fs contained in wastes produced by the incinerator into the environment

In contrast to similar plants in the Czech Republic, measurements of dioxin contents were carried out in wastes produced at the Liberec incinerator. The basic results of these measurements are shown in Table 7. In addition to these, the level of 0.2136 ng I-TEQ/g was found in the mixture of fly and bottom ash[92]. The operator of the incinerator somehow had the mixture of ashes reclassified as waste that does not have hazardous characteristics and since the year 2001 have possessed a certificate according to which this mixture can be marketed as a construction material.

Any mixture of fly ash and bottom ash will contain high concentrations of dioxins, which, in the case of fly ash used in Newcastle, resulted in the contamination of eggs and poultry in the vicinity of where it was spread.[93]. Therefore, such ashes should be

Table 7. : Results of measurements of dioxin contents in bottom ash and fly ash in Liberec[a, a].

Type of waste	Measurement No. 1 ng I-TEQ/g	Measurement No. 2 ng I-TEQ/g
bottom ash (2911)	0.00437	0.0197
treated fly ash (2912)	0.362	0.363
mixed bottom ash with treated fly ash (2913)	0.062	0.066
boiler ash (11249)*	0.0113	-

included into the calculation of total releases of PCDD/Fs into the environment.

UNEP prepared a proposal of "Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases", with an attached 'tool' for the calculation of total releases of dioxins into the environment with emission factors. We have tried to use this Toolkit to calculate the amounts of PCDD/Fs in the wastes produced by the Liberec incinerator. The result is shown in Table 8. Following this we made the same calculation using known information concerning the amounts of wastes produced by the Liberec incinerator on the levels of dioxins found in these wastes. Data for waste waters, as well as for filter cake, are not available[1].

For calculations concerning the year 2003, only estimates of releases of PCDD/Fs in product/material, for which the mixture of fly and bottom ash was certified could be made. Our calculations were based on data of waste production given by the incinerator in an application for issuance of IPPC certificate. Information on the calculations are contained in Table 9.

Table 8: Calculation of PCDD/Fs releases per year for MWI in Liberec based on UNEP's Toolkit and on real measurements.

	Annual release						Total annual release in g TEQ/a
	g TEQ/a Air	g TEQ/a Water[a]	g TEQ/a Land[a]	g TEQ/a Products	g TEQ/a Fly ash	g TEQ/a Bottom Ash	
Toolkit	0.048	0	0	0	1.44	0.144	**1.584**
Reality 2002a	0.0898	?	?	0	0.3828	8.2780	**8.7506**
Reality 2002b	0.0898	?	?	0	0.3828	2.4030	**2.8756**
Reality 2003a	0.037	?	?	8	0.4203	0.1440	**8.6013**
Reality 2003b	0.037	?	?	2.25	0.4203	0.1440	**2.8513**

In each of the cases calculation according to real values has been carried out in two variants designated "a" and "b", in view of the fact that levels of dioxins found out in the mixture of fly ash with bottom ash differ significantly. The real amount of dioxins contained in this waste is likely to be somewhere between both variants.

Table 9: Amounts of residues produced by MWI in Liberec per year[a].

Type of waste	Amounts of produced waste per year in		
	2001	2002	2003
Filter cake (19 01 05)	1085,22	1051,44	1154,8
Waste water from flue gases treatment etc. (19 01 06)	106,12	121,54	21,5 *
Bottom ash (19 01 12) **	33 703,92	38 754,17	2316,09 ***
Other ashes (mainly boiler ash; 19 01 13)	128	113	92

* only amount transferred out of the plant included - waste water treated at plant's waste water treatment facility is not included in this number

** there is also treated fly ash included in this figure

*** biggest part of this waste has been used as product (construction material) since the beginning of 2003, so the amount of this "product" is not included here.

[1] For our calculation, we have used the concentration of dioxins found in treated fly ash and for the filter cake. In reality, it can be expected that the filter cake contains much higher level of dioxins than in our calculation.

In the case of the calculation according to the Toolkit[94], in comparison with calculation based on measured values vastly different numbers

were obtained. This was a result of several factors:

1) The Toolkit supposes much lower amount of residual wastes after the combustion of one ton of solid municipal waste.

2) The Toolkit does not consider the mixing of fly and bottom ash. This resulted in much lower level of dioxins in bottom ash being set.

3) Emission factors for releases of PCDD/Fs into the environment are given as simple numbers without ranges.

The difference between the calculation according to the Toolkit and reality will continue to increase after concentration of dioxins in waste waters from Liberec are known. These are not taken into account in the case of municipal waste incinerators in the Toolkit.

Picture 16: Sampling of sediments in surroundings of an old coal mine Jan Šverma near Lampertice at the beginning of 2004. Photo by: Jindřich Petrlík.

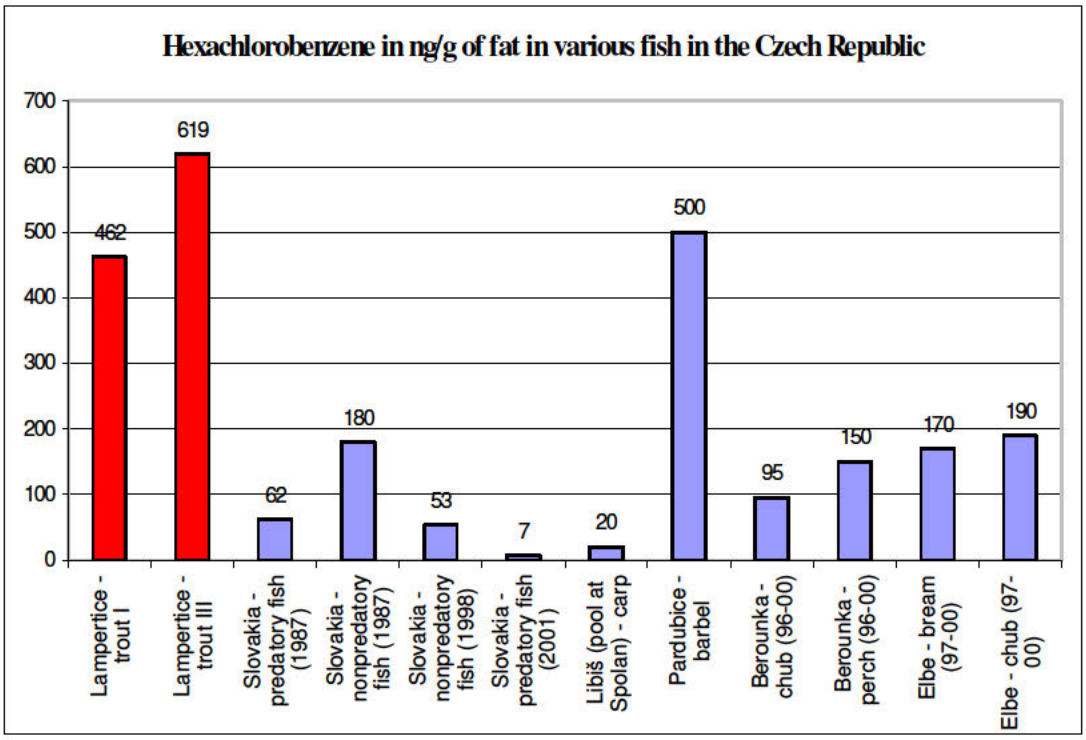
8.2.2 Lampertice

There have been black coal mine workings under the highest Czech mountains Krkonose (German synono-nyma Riesengebirge) in the northeast part of the Bohemia since the 16th century. The oldest underground mine was later called Mine Jan Šverma and is located between the town of Žacléř and the village of Lampertice. This mine was closed sometime around 1990.

The mine is located in an area with typical under-mountain landscape with a wild Lampertický creek. There is also a complicated underground water system that, according to the experts of the GEMEC Union company (working on the mine reclamation), doesn't leak from the mine. However local people who worked in the mine don't trust this opinion and say that the situation is much more complicated than most people believe. The Mine itself is located next to the Czech - Polish boarders, so any changes in the environment could well have transboundary impact.

It is common practice that these old mines are filled with different materials to prevent surface landscape movements. We have chosen this particular mine for our hot spot report as it has been filled with different types of wastes, including wastes showing POPs patterns. According to records of state environment control insitutions the waste incineration residues were stored in this mine in amounts up to 7000 tons per year.[95]

The basic argument of the GEMEC Union company is that the technology used is safe and that the leaching of toxic substances deposited in the mine does not occur. However, the results of tests of sediments from Lampertice stream showed that in one place (below a discharge from the waste water treatment plant in the premises of the mine), the dioxins concentration is ten times the amount of the lowest value found in the area (this is a tributary of Lampertice stream "U Kirschů", which drains the south part of the spoil heap). The measured values show without doubt the necessity and importance of a thorough environmental impact assessment of the



Picture 17: Graph showing comparison of concentrations of hexachlorobenzene measured in fat of fish from different localities.

chosen method of re-cultivation or liquidation of the underground mine.

At the first half of year 2004 the Arnika Association published results of analysis of four trout samples for different POPs. From the analyzed substances, the trout from Lampertice contained the highest values of hexachlorobenzene in comparison with the other locations in the Czech Republic as showed from the comparison presented in the graph at Picture17.[96] Also the value of indicator congeners of PCBs in the case of trout I was relatively high. Trout III values were lower, but also significant in comparison with values found in Slovakia in the years 1987 - 2001.[97]

8.3 Barangay Aguado, Philippines

Barangay Aguado is "home" to a controversial "Thermal Oxidizer Plant" operated by Integrated Waste Management Inc. (IWMI). A typi-cal incinerator had operated in the same site for over four years. The IWMI incinerator is a "pyrolytic waste oxidizer" from Canada-based EcoWaste Solutions Inc., with a capacity of 10 tons/day. Apart from treating biomedical waste coming from client hospitals in Metro Manila, the IWMI incinerator also accepts and burns illegal drugs such as amphetamines seized from drug syndicates.

The IWMI "Thermal Oxidizer Plant" was formally inaugurated in September 2003, in apparent defiance of the ban on medical waste incineration that took effect under the Clean Air Act in July 2003.

The IWMI claims that the residual ash from its facility is safe based on test procedures that do not measure dioxins. Tests conducted in 1998 for EcoWaste Solutions technology show significant levels of dioxins in the ash at 23 ng TEQ/kg of waste.[98]

NGO representatives present at the official launch of the IWMI facility were told that the bottom ash is mixed with cement to make concrete blocks. The hollow blocks, as they are called in the Philippines, are also mixed with industrial waste, i.e., shredded computer hardware scraps, which could also be the

Picture 18: Protest action opposing the construction of the IWMI waste incinerator in Barangay Aguado, Philippines. Photo by: Green Cavite.

source of high levels of polybrominated diphenyl ethers (PBDEs) [99] observed in free range chicken eggs sampled near IWMI's facility in Barangay Aguado, Philippines.

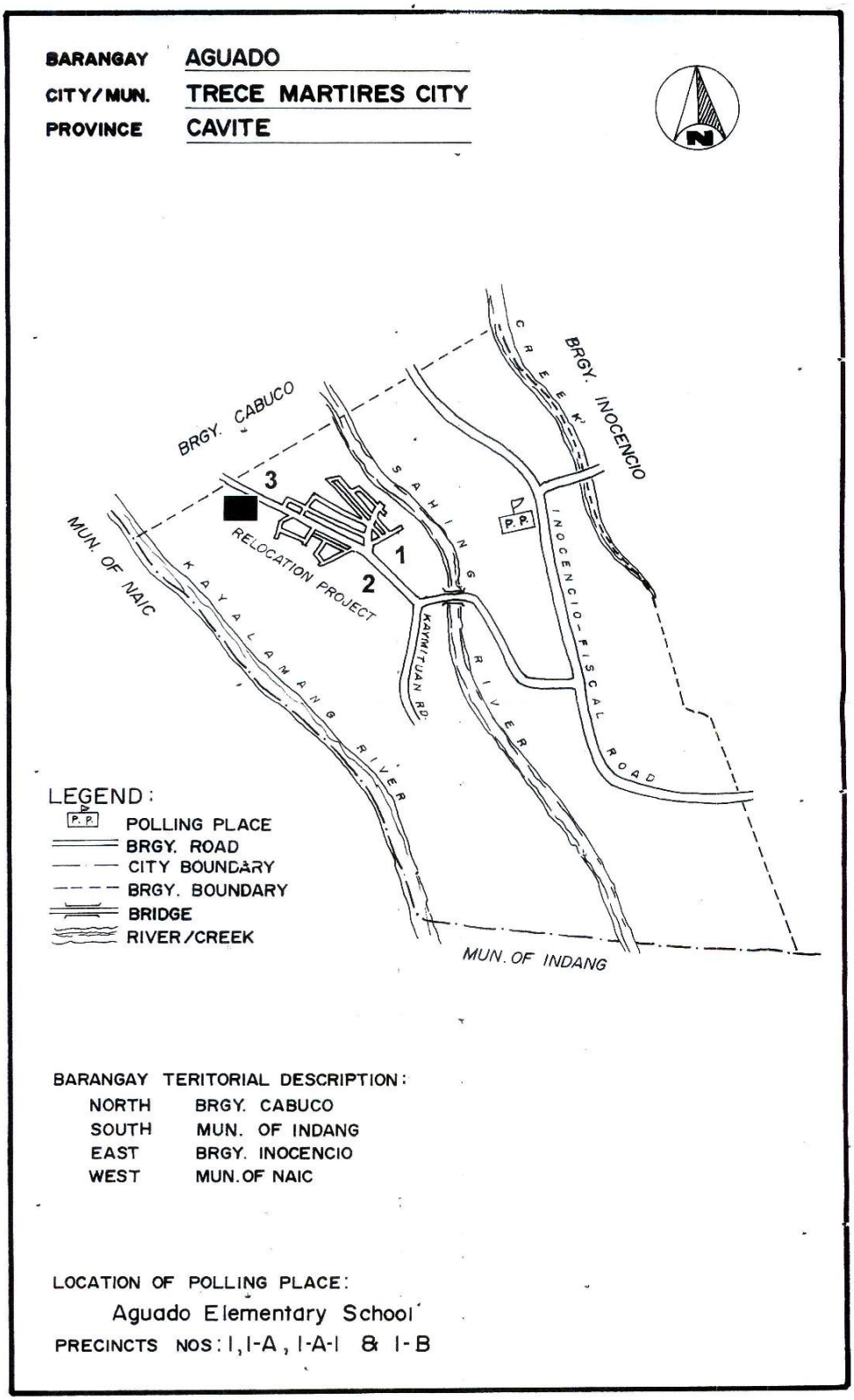
The communities, including Barangay Aguado and nearby Barangays, are possibly the most affected by the continued operation of the IWMI waste incinerator. The lack of a secured facility for containing the incinerator ash, and its use for making concrete blocks could only aggravate the spread of toxic pollutants into the air, water and soil. The vicinity map shows the existence of waterways (two rivers and a creek), a common source for water and fish, not far from the IWMI waste treatment plant (see Picture 19). [100]

Free-range chicken eggs collected near the medi-cal waste incinerator in Barangay Aguado showed levels of dioxins[m] that exceeded the European Union (EU) limit by more than 3-fold. Additionally the level of PCBs in the eggs[n] exceeded the proposed EU limit. The levels of 7 PCB congeners did not exceed regulatory limits but were the seventh highest observed among 20 samples analyzed during IPEN's global biomonitoring project.[101] The reasons for this substantial level of PCBs are not clear. The three egg sampling sites were approximately half a kilometer northeast of the incineration plant.

Comparing the dioxin congener pattern from eggs collected in Barangay Aguado with data measured for different kinds of sources from other countries indicates that medical waste incineration (including fly ash and air releases) is the likely source of the dioxins found in the eggs. Data from other types of dioxin sources such as metallurgy and/or local heating using wooden materials show different patterns of dioxin congeners.

[m] 9.68 pg WHO-TEQ/g of fat

[n] 3.30 pg WHO-TEQ/g of fat



Picture 19: Map showing the Barangay Aguado detailed situation. The black spot is the IWMI medical waste incinerator and numbers 1, 2 and 3 are marked sampling sites of free-range chicken eggs. The map shows also waterways – a possible pollution pathway.

9. Waste incineration residues questions and the Stockholm Convention

9.1 How much is a "LOW" content of POPs?

The content of POPs in waste is one of focuses of the Stockholm Convention in which Article 6 states: "Measures to reduce or eliminate releases from stockpiles and wastes" -- instructs the Stockholm Conference of Parties to cooperate closely with the appropriate bodies of the Basel Convention to:
"*establish levels of destruction and irreversible transformation necessary to ensure that the characteristics of persistent organic pollutants … are not exhibited";*
"determine what they consider to be the methods that constitute environmentally sound disposal"; and
"work to establish, as appropriate the concentration levels of the chemicals listed in Annexes A, B and C in order to define the low persistent organic pollutant content" below which POPs wastes need not undergo destruction or irreversible transformation, but are to be disposed of in an environmentally sound manner.

In response to Article 6, the Basel Convention Open Ended Working Group (OEWG) undertook the task of preparing a series of guidelines on wastes consisting of or containing POPs. The first two guidelines in the series – "General Technical Guidelines for Environmentally Sound Management of Wastes Consisting of, Containing or Contaminated with Persistent Organic Pollutants," and "Technical Guidelines for Environmentally Sound Management of Wastes Consisting of, Containing or Contaminated with Polychlorinated Biphenyls, Polychlorinated Terphenyls or Polybrominated Biphenyls" -- were approved and adopted at the sixth Conference of Parties (COP6) of the Basel Convention, 25–29 October 2004. [102, 103]

The Basel Convention Technical Guidelines has proposed levels of most POPs in wastes/residues that trigger the requirement for destruction or irreversible transformation of 15 ppb (in I-TEQ) for PCDD/Fs and 50 ppm for all other POPs listed in Annexes to Stockholm Convention. Low POP content levels as required in Article 6 of the Stockholm Convention are proposed at the same levels. Delegates at COP will have the opportunity to tighten these guidelines so that they provide greater protection to human health and the environment.

The proposed levels are not based on practical experience or on current knowledge about the levels in POPs wastes in relation to recorded examples of high environment and food chain contamination.

It is shown in this study that the majority of residues from waste incineration contain levels of dioxins that are below the proposed low POP content as well as bellow the level that requires further treatment to ensure that "*the characteristics of persistent organic pollutants … are not exhibited"*. Does this mean that use of waste incineration residues cannot harm the environment and public health?

Looking at the examples in this study the clear answer on this question is NO! The level established for dioxins (PCDD/Fs) at 15 ng I-TEQ/g is very high if we consider one example from UK, where waste incineration fly ash was spread on the allotments and poultry was contaminated by unacceptably high levels of dioxins. Fly ash spread on the allotments contained levels of dioxins in the range of 0.020 - 4.224 ng I-TEQ/g dry matter and contamination by this waste led to contamination of poultry eggs, up to 56 pg WHO-TEQ/g on lipid base.[104] EU limit set up for dioxins content in eggs is at 3 pg WHO-TEQ/g on lipid base which was exceeded by almost all eggs samples from Newcastle upon Tyne measured after that accident.

There are more documented cases of unsafe treatment of the wastes containing POPs which led and/or contributed to increased levels of POPs in the environment and food chain. Some of these were recently documented by series of studies on hot spots in different countries. These studies showed elevated levels of dioxins and other U-POPs in collected free

range chicken eggs sited near the hot spots. In some of these cases the high levels of dioxins were found to be related to wastes containing POPs. For example: the case of chicken eggs sampled in Philippines near a medical waste incinerator in Barangay Aguado where incineration residues are used for production of concrete "hollow blocks". The eggs collected near the incinerator showed very high levels similar to the waste incineration residues pattern of dioxin congeners. [105] Another case of eggs found with high dioxin contents in the mentioned studies is those taken from near the chlorinated waste disposal area of the poorly controlled chlorine chemical industries in Dzerzhinsk.[106]

The case of the village Lampertice in the Czech Republic shows that to allow POPs waste to be stored in the areas of old coal mines and the handling of these wastes in these areas can lead to serious threats of the environment. Here one of the highest levels of hexachlorobenzene in fish was recorded, a find that is most probably a result of the dumping of large quantities of wastes containing POPs, the including waste incineration residues and sewage sludge from the chlorine chemical industry.[107]

The myth about non-leachable dioxins (and other U-POPs) from ash, (which is to blame for new findings as shown in this study), together with the proposed limits for POPs content in waste under the Stockholm Convention can and will (if accepted), undoubtedly lead to unacceptable contamination by POPs and goes against the very essence of the treaty. Not only that. The Basel Convention Technical Guidelinse proposed levels of POPs in waste undermines some national legislation efforts.

In Japan, after a few serious dioxin incidents at incineration facilities, resulting in some facilities shut down, the government published a new act, effective since April 2000, in which levels of dioxins and coplanar PCBs in fly ash are regulated.

The limit for dioxins and dioxin-like PCBs content in fly ash was set by that regulation at level of 3 ng TEQ/g, what is 5-times lower in comparison to the proposed level for adoption at COP of the Stockholm Convention.[108] Similarly "destruction and irreversible transformation" level for dioxins content in waste is contrary to the Czech legislation. Levels of PCDD/Fs content in the soils which requires clean up of the area where this limit is not met is 10 ng/g[o] for industrial zones and 0.5 ng/g for living urban zones, both in I-TEQ. For seven PCB congeners these limits are 30 and 5 mg/kg. respectively, for organochlorine pesticides these levels are 10 and 2.5 mg/kg.[109]

9.2 Dioxins in ashes according to Dioxin Toolkit

UNEP has developed a basic tool to help parties to the Stockholm Convention develop their national POPs inventories which focused on dioxins. This Dioxin 'Toolkit' get its name from the longer "Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases".[110] Countries can calculate basic dioxins releases from different sources on this inventory and address major sources to comply with the aims of the Stockholm Convention to minimize and where feasible, to eliminate U-POPs. From these consequences we can see how important the Toolkit is.

There was published a comprehensive number of data about waste incineration residue production and dioxin levels in them in England and Wales.[111] We used this data to calculate dioxin releases in waste incineration residues produced by eleven municipal waste incinerators in England and Wales and their emission factors[p] for incineration residues. This calculation was based on measured maximum levels of dioxins in the residues is in Table 10.

[o] This and following Czech limits are per kg of dry matter.

[p] "emission factors" describe release of PCDD/PCDF to each medium per unit of activity (*e.g.,* µg I-TEQ/ton) - this is definition in UNEP Toolkit. These emission factors are calculated from measured levels of PCDD/Fs, quantitaties of emmitted medium for which the emission factor is calculated and quantitative data about activity (= burnt waste per year for waste incineration)

We have tried to compare the emission factors calculated from the average and maximum levels of dioxins in waste incineration residues from England and Wales with those used for state of art municipal waste incinerators in UNEP Toolkit (= MWI class 4). The emission factors calculated from the real life data are quite different from emission factors used in UNEP Toolkit (see Table 11). For fly ash the emission factor used in UNEP Toolkit is 15 µg I-TEQ/t of burned waste, while the emission factors calculated from real life data is between the range of 23 to 70 µg I-TEQ/t of burned waste.

10. Conclusions and Recommendations

Waste incineration residues represent a serious threat to both local and global environment as they contain high quantities of persistent organic pollutants (POPs) listed under Annex C of the Stockholm Convention (dioxins, PCBs and hexachlorobenzene) as unintentionally produced POPs. A goal of the ***"continuing minimization and, where feasible, ultimate elimination"*** was established for these chemicals in the Convention. There are several steps that should help Parties to the Stockholm Convention to comply to this goal. Almost all are under articles 5 and 6 of the Stockholm Convention (see Annexes to this text) and are discussed at the Conference of Parties to the Convention.. Topics discussed in this study are related to several of these steps.

1) Basel Convention versus Stockholm Convention

"Levels of destruction and irreversible transformation of POPs in waste" and "Low POPs levels in waste"

POPs require guidelines for management and disposal but the proposed Basel Convention levels of most POPs in wastes that trigger the requirement for destruction or irreversible transformation are quite permissive at 15 ppb (in I-TEQ) for PCDD/Fs and 50 ppm for all other POPs listed in Annexes to Stockholm Convention (see "General technical guidelines …."). Delegates at COP will have the opportunity to tighten these guidelines so that they provide greater protection to human health and the environment.

For example, level established for dioxins (PCDD/Fs) at 15 ng I-TEQ/g is really high if we consider the example from the UK. Here waste incineration fly ash was spread on the allotments and poultry kept on these sites was contaminated by high levels of dioxins. The fly ash spread contained levels of dioxins in the range of 0.020 - 4.224 ng I-TEQ/g dry weight and its consumption by the chickens led to the contamination of poultry eggs up to 56 pg WHO-TEQ/g on lipid base.[112] The EU limit for dioxins content in eggs is 3 pg WHO-TEQ/g on lipid base, which was exceeded by almost all the eggs samples from Newcastle measured after this irresponsible action.

The decision taken by Conference of Parties to Basel Convention on the levels of destruction and irreversible transformation is equally as irresponsible and doesn't comply with the Stockholm Convention definition and requirements in its article 6. No ***"levels of destruction and irreversible transformation"*** were established ***"to ensure that the characteristics of persistent organic pollutants as specified in paragraph 1 of Annex D are not exhibited;"*** as required in article 6 of the Stockholm Convention. Basel Convention technical guidelines redefined ***"levels of destruction and irreversible transformation"*** instead.

The myth about non-leachable dioxins (and other U-POPs) from ash, which is to blame for new findings as shown in this study, together with limits for POPs content in waste under the Stockholm Convention proposed can lead to unacceptable contamination by POPs, going against the aim of the treaty. Not only that. By the Basel Convention Technical Guidelinse proposed levels of POPs in waste undermine some national legislation efforts.

3) BAT/BEP Guidelines

Looking at these facts it is unbelievable how the use of these materials is out of control to the extent they are in many countries. There are plenty of studies showing the use of waste incineration fly ash as construction materials based on leaching analysis for heavy metals. This practice is in strong disagreement with one of goals of the Stockholm Convention and several hot spots cases presented in this study shown that uncontrolled use of fly ash as construction materials can lead to serious damage of the environment and threaten the health of communities living in the vicinity and surrounding areas where this material was used and/or where this material is produced. Therefore we suggest to incorporate the use of non-combustion chemical treatment methods that lead to real POPs destruction into BAT/BEP Guidelines.

4) New POPs

Dioxins were not the only toxic organic chemical studied in waste incineration residues. PCBs and hexachlorobenzene in waste incineration residues were also look at. Many of these chemicals show the same and/or similar behavior as those already listed under Annex C of the Stockholm Convention. These findings suggest these should be added those listed in Annex C, especially the polychlorinated naphthalens (PCNs), polybrominated dioxins and furans (PBDD/Fs and PCBDD/Fs) and polyaromatic hydrocarbons (PAHs).

5) The precautionary principle is included in the Convention and applied to the issue of waste incineration residues. This leads to the recommendation that the best available technique and best environmental practice are used to prevent the production of such wastes. It also means the preferencial use of technologies other than waste incineration and/or landfilling and that chlorinated and brominated compounds lead to chlorinated and brominated POPs occuring suggesting the substitution of materials containing these chemicals.

Table 10: Measured maximum levels of dioxins in waste incineration residues from municipal waste incinerators, other data about MWI residues and calculated maximal emission default factors for MWI in England and Wales. Based on data published in EA 2002. [113]

Municipal waste incinerator	Bolton	Coventry	Dudley	Edmonton	Nottingham	Lewisham	Sheffield	Stoke on Trent	Teesside	Birmingham	Wolverhampton	Sums (average) *
Waste burnt in tonnes	30300	201446	99492	500730	159817	437850	103644	201752	213839	335959	119011	2403840
Bottom ash in tonnes	11904	33148	21132	157582	37938	107923	39852	50001	76724	77054	28830	642088
Bottom ash in % of burnt waste	39.29	16.46	21.24	31.47	23.74	24.65	38.45	24.78	35.88	22.94	24.22	26.71
APC residues in tonnes	1353	7194	4178	15858	7328	14840	3333	6472	5848	8717	4650	79771
APC residues in % of burnt waste	4.47	3.57	4.20	3.17	4.59	3.39	3.22	3.21	2.73	2.59	3.91	3.32
PCDD/Fs in bottom ash in ng I-TEQ/kg	13.0	10.5	7.8	23.0	4.9	4.3	52.0	21.0	12.0	7.4	6.4	4.3 - 52.0
PCDD/Fs in bottom ash g I-TEQ/year	0.15	0.35	0.16	3.62	0.19	0.46	2.07	1.05	0.92	0.57	0.18	9.74
PCDD/Fs in APC residues in ng I-TEQ/kg	330	2591	1125	5800	697	720	1200	823	370	1364	2753	330 - 5800
PCDD/Fs in APC residues in g I-TEQ/year	0.45	18.64	4.70	91.98	5.11	10.68	4.00	5.33	2.16	11.89	12.80	167.74
Emission factor / bottom ash in µg I-TEQ/t	5.11	1.73	1.66	7.24	1.16	1.06	19.99	5.20	4.31	1.70	1.55	4.05
Emission factor / APC residues in µg I-TEQ/t	14.74	92.53	47.24	183.68	31.96	24.40	38.59	26.40	10.12	35.39	107.57	69.78

Notes: * average of % of residues of burnt waste (both APC and bottom ash), range of maximum levels of PCDD/Fs measured in residues, (both APC and bottom ash), **average default factors**

Table 11: Emission default factors calculations for MWI in England and Wales based on data from EA 2002.[114] Comparison with emission default factor and basic data for its calculation from UNEP Toolkit. [115]

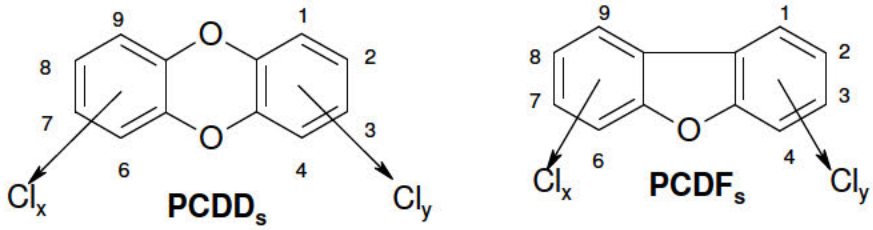
Type of estimates / calculations	Based on measured max. levels	Calculated from average max. level	Calculated from median max. level	Based on measured average levels	Calculated from medium of average levels	Calculated from median of average levels	UNEP Toolkit - class 4
Waste burnt in tonnes	**2403840**	2403840	2403840	**2403840**	2403840	2403840	**2403840**
Bottom ash in % of burnt waste	**26.71**	26.71	26.71	**26.71**	26.71	26.71	**10 - 20**
APC residues in % of burnt waste	**3.32**	3.32	3.32	**3.32**	3.32	3.32	**1 - 2**
PCDD/Fs in bottom ash in ng I-TEQ/kg	**4.3 - 52.0**	14.8	10.5	**2.5 - 25**	7.4	5.0	**5.0**
PCDD/Fs in bottom ash g I-TEQ/year	**9.7**	9.5	6.7	**4.8**	4.7	3.2	**3.6**
PCDD/Fs in APC residues in ng I-TEQ/kg	**330 - 5800**	1615.7	1125.0	**270 - 2800**	993.2	700.0	**1000.0**
PCDD/Fs in APC residues in g I-TEQ/year	**167.7**	128.9	89.7	**94.3**	79.2	55.8	**36.1**
Emission factor / bottom ash in µg I-TEQ/t	**4.1**	3.9	2.8	**2.0**	2.0	1.3	**1.5**
Emission factor / APC residues in µg I-TEQ/t	**69.8**	**53.6**	**37.3**	**39.2**	**33.0**	**23.2**	**15.0**

Annex 1. Chemical profiles of U-POPs

Dioxins and Furans

Structure and properties

Dioxins (polychlorinated dibenzo-p-dioxins, or PCDDs) and furans (polychlorinated dibenzofurans, or PCDFs) are two groups of chemicals with similar chemical structures **(Picture 2.1)** each varying according to the number and position of chlorine atoms attached to the dioxin or furan moiety. There are 75 different dioxins and 135 different furans. The number and placement of their chlorine atoms also determines their physical, chemical, and toxicological properties.



Picture 2.1 Structure of polychlorinated dibenzo-p-dioxins and d benzofurans (PCDDs/Fs)

Dioxins show very low solubility in water (especially the ones that are highly chlorinated), and low volatility, they are readily absorbed on the surface of solid particles, and decompose very slowly. As a result of these characteristics, Dioxins are found primarily in soil, sludge and sediments, and in very limited amounts in the dissolved form in surface or other waters. Due to a high distribution coefficient, (known as Kow), they are able to bioaccumulate in the adipose tissues of animals and people.

Sources

Among the most significant dioxin sources are waste incinerators (including municipal waste incinerators), iron ore sintering plants, production and use of the wood preservative pentachlorophenol, and pulp and paper mills using chlorine for the bleaching process. PCBs are the most significant potential source of furans, a fact that underlies the concern about accidental burning of PCBs.

Toxicity

A number of types of cancers, as well as total cancer incidence, have been related to accidental and occupational exposure to one particular dioxin, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), the most toxic of the dioxins. (See references at the end of the Annex) In their recently published book, Schecter and Gasiewicz note that recent data ". . . provide evidence for reproductive, developmental, and immunotoxic effects in humans." In addition, an increased prevalence of diabetes and increased mortality due to diabetes and cardiovascular diseases has been reported. In children exposed to dioxins, effects on neurodevelopment, neurobehavioral and effects on thyroid hormone status have been reported at exposures at or near background levels. At higher exposures, due to accidental exposure (Yusho and Yu Cheng populations), children exposed transplacentally to dioxins show skin defects (such as chloracne), tooth mineralization defects, developmental delays, behavior disorders, decrease in penile length at puberty, reduced height among girls at puberty and hearing loss.

Dioxins and furans persist for long periods and everyone is exposed to them. They enter the human body by ingestion, inhalation, and skin penetration. The most important route for human exposure to dioxins is food consumption, contributing more than 90% of total exposure, of which products of fish and other animal origins account for approximately 80%.

Forty specialists from 15 countries met at the headquarters of the World Health Organization (WHO) in Geneva from 25 to 29 May 1998 to

evaluate the risks which dioxins might cause to health. After ample debate, the specialists agreed on a new tolerable daily intake range of 1 to 4 picogrammes/kilogram body weight. The experts, however, recognized that subtle effects may already occur in the general population in developed countries at current background levels of 2 to 6 picogrammes/kilogram body weight. They therefore recommended that every effort should be made to reduce exposure "…to the lowest possible level."

Polychlorinated biphenyls (PCBs)

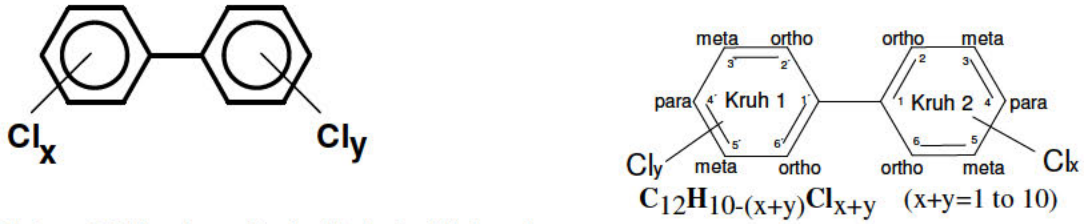
Structure

PCBs are organic compounds which have hydrogen atoms on the biphenyl skeleton replaced, to various extents, by chlorine atoms. The number of chlorine atoms in the molecule can range from 1 to 10, and theoretically 209 isomers (congeners) of PCBs can exist (Picture 2.2). However, only about 100 congeners prevail in industrially produced mixtures of

In the 1970s, countries of the Organization for Economic Co-operation and Development (OECD) restricted the use of PCBs to closed systems. Manufacture for export to non-OECD countries continued in Europe until 1983. Currently, 16 countries prohibit the import of PCBs, whereas six others allow the import of PCBs only under special circumstances. However, PCBs are in use in numerous countries worldwide.

Monsanto, Bayer, DSW-VEB, Caffaro, S.A. Cros, Prodelec and others produced PCBs intentionally under various trade names including "Arochlor", "Pyrochlor", "Asbestol", "Askarel", "Bakola", "Chlorinol", "Chlorphen", "Fenochlor", "Dykanol", "Orophene", "Clophen", "Pyranol", "Saft-T-Kuhl" and "Sovol".

PCBs are created as unintentional by-products from many of the sources that generate dioxins. They are produced during the combustion of organic materials containing chlorine as well as during the manufacture of various chlorine-containing chemicals, such as



Picture 2.2 Structure of polychlorinated biphenyls

PCBs. The proposed Toxic Equivalency Factors from the World Health Organization for dioxin-like PCBs range over four orders of magnitude.

Sources

The chemical stability and heat resistance of PCBs led to their extensive intentional use in two types of applications:

1) closed uses – dielectric fluids in electrical equipment such as transformers, capacitors, heat transfer and hydraulic systems; and
2) open uses – as pesticide extenders, sealants, in carbonless copy paper, industrial oils, paints, adhesives, plastics, flame retardants and to control dust on roads. This use was widely banned in the 1970s.

ethylene dichloride. A study of PCB release from unintentional sources found that industrial coal combustion produced significant levels of PCBs expressed as TEQ, though they represented only a small fraction of the total PCBs. [116] Other unintentional sources include municipal waste incineration, electric arc furnaces, shredders, sinter plants, cement plants, crematoria, and coal-based power stations. [117 118 119]

Releases

A major source of PCBs expressed either as mass or TEQ is leakage from capacitors and transformers. Ongoing releases of PCBs to the environment occur from fires, spills, and leaks from closed systems; evaporation or leakage

from landfills or PCB storage sites; incineration of waste containing PCBs (which were once used in a wide array of consumer products); and incomplete incineration of waste PCBs. PCBs released to the environment can be accompanied by the presence of dioxins.

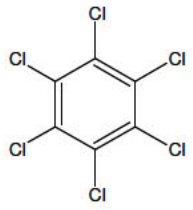
Toxicity

PCBs are classified as probable human carcinogens (group 2A) by IARC and produce a wide spectrum of adverse effects in animals, including reproductive toxicity and immunotoxicity. Prenatal exposure to PCBs is associated with reduced concentration and poorer verbal, pictorial, and auditory working memory in humans. The most common route of PCB entry into humans is ingestion of contaminated food, including fish; however, PCBs may also be inhaled and absorbed through the skin. PCBs are extremely persistent and accumulate, especially in adipose tissues. They are bioaccumulated from water and river sediments by algae and plankton and thereby enter food chains. The distribution coefficients between water and fat for the individual congeners of PCBs are so high that experimental fish kept for a longer time in water contaminated by trace concentrations of PCB concentrated these substances in their bodies up to a thousand-times. The distribution of PCBs in the bodies of fish is not uniform. For example, in carp, they accumulate especially in adipose tissues, head, central nervous system, gallbladder, and other internal organs. In contrast, concentrations in blood and smooth muscles are significantly lower.

Hexachlorobenzene - HCB

Structure and properties

HCB (Picture 2.3) is a white crystalline solid or crystal and is used as a fungicide.



Picture 2. 3: Stucture of HCB

HCB is a very stable, low volatile compound of lipophilic nature showing low solubility in water, and considerable ability to accumulate in adipose tissues of organisms and to absorb on surfaces of solid particles. It decomposes only very slowly in the environment. In the scientific literature, chlorinated phenols are mentioned as its decomposition products. These properties of HCB result in long persistence in the environment and its entry into food chains.

Sources

HCB was originally introduced in 1940's as a seed-dressing for cereal crops to prevent fungal disease. HCB is used as fungicide, disinfectant, and as a starting or intermediate raw material during production of certain chemicals (pentachlorophenol, some chlorinated aromatic compounds). As an industrial chemical, it is used, for example, in production of pyrotechnic products, synthetic rubber and aluminum. For its fungicide properties it was used for treatment of wheat and onion, and for seed treatment. HCB has also been used in various industrial processes, for example, as a fluxing agent in the manufacture of aluminum and as a dispersing agent in the production of rubber for tires. HCB was voluntarily cancelled for use as a pesticide in 1984 in the U.S. and is no longer commercially manufactured as an end product in that country. It is also banned in India and Japan and its use is restricted in several other countries. However, it may still be in use in several countries.

HCB also produced as an unintentional by-product of combustion processes involving chlorinated compounds (for example, during waste incineration or in metallurgy) and as a by-product in the manufacture of certain chlorinated pesticides (such as lindane) and industrial chemicals (for example, in chlorine chemistry or during chlorine bleaching of pulp). In this latter group are chlorinated solvents, such as carbon tetrachloride, perchloroethylene, trichloroethylene and chlorinated benzenes.

Toxicity

HCB is toxic to both humans and animals when long-term exposure occurs. Its main health effect is liver disease. HCB is also

known as an endocrine disruptor and probable human carcinogen (2B category according to IARC ranking). Human exposure to HCB may occur through several pathways including consumption of dairy products or meat from cattle grazing on contaminated pastures; consuming low levels in food, eating or touching contaminated soil; drinking small amounts in contaminated water; inhaling low levels in contaminated air; drinking contaminated breast milk from exposed mothers; occupational exposure from the use or production of HCB; and exposure to HCB as a by-product from other industrial processes, such as waste incineration.

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Annex 2: Overview of POPs content in ashes

Table 1: PCDD/Fs - Fly ash

Country	Type of incinerator	Year/date of measurement	Specification	Type of value (mean, med, max, min etc.)	Measured level in ng/kg (I-TEQ) of dry weight	Source of information
Turkey – Izmit	haz./medical waste	April 2000	ESP ash		280	13
Thailand	MWI	1997 - 2001	APC residue		228	10
Thailand	MWI	1997 - 2001	APC residue		380	10
Thailand	MWI	1997 - 2001	APC residue		686	10
Thailand	MWI	1997 - 2001	fly ash	average conc.	431	10
Thailand	MWI	1997 - 2001	fly ash	average conc.	468*	10
Czech Republic	Haz. waste incinerator	not specified	fly ash		860	
Russia – Moscow	MWI	1998	electrostatic filter ash		1160-5890	21
Russia – Moscow	MWI	1998	ceramic filter ash		8590-12050	21
Russia – Moscow	MWI	1998	heat exchanger ash		950	21
Czech Republic	Haz. waste incinerator	before 2003	fly ash		82400	19
Czech Republic	waste incinerator	1999	fly ash		1153,1	2
Czech Republic	waste incinerator	2000	sorbalit (APC residue)		1400	2
Czech Republic - Lysa nad Labem	Haz. waste incinerator	2000	sorbalit (APC residue)	range	2190-6310	25
Czech Republic – Liberec	MWI	2000	fly ash after it was treated		362	27
Czech Republic – Liberec	MWI	1999	boiler ash		11,3	2
Czech Republic	waste incinerator	2000	fly ash	range	1100-3000	2
Czech Republic	waste incinerator	2004	fly ash		930	7
UK – Bolton	waste incinerator	2001	fly ash		460	2
Germany	MWI	1994	fly ash	range	110-2300	9
UK Byker/Blucher allotment – Newcastle	MWI	199?	fly ash		9500	24
Germany	MWI	1997	fly ash	range	440-11200	26

Table 1 continued

Japan	small scale incinerators and MWI	1998	fly ash	range	2000-2100000	11
Taiwan	MSW, 450 t/24 hours, dry scrubber + fabric filter	1998	fly ash	range	256-2526	14
Taiwan	MSW, 300 t/24 hours, electrostatic precipitators+ wet scrubber	1998	fly ash		6953	14
Taiwan	MSW, 300 t/24 hours, electrostatic precipitators+ wet scrubber	1998	fly ash		1592	14
Taiwan	MSW, 75 t/24 hours, semidry scrubber + fabric filter	1998	fly ash		23795	14
Taiwan	MSW, 30 t/16 hours, semidry scrubber + ESP	1998	fly ash		28917	14
Taiwan	Medical waste incin., 3.6 t/8 hours, venturi wet scrubber	1998	fly ash		13266	14
UK - England and Wales	MWI	2002	fly ash	range	200-5800	5
Sweden	waste incinerators	1999		range	2000-3000	20
Japan	MWI	2001	fly ash pellets		862	12
Sweden	MWI	2002	APC residue	average conc.	200	1
Netherlands	waste incinerators		fly ash		2400	17
Italy	MWI	2003	fly ash		58056	15
Italy	MWI	2003	fly ash		6473	15
Italy	MWI	2003	fly ash		36	15
Czech Republic - Klasterec nad Ohri	HWI/MWI	1999	fly ash		21400	23
Korea	MWI	2003	fly ash		6726	22
UK	waste incinerators	1996	fly ash	range	191-1820	8

Table 2: PCDD/Fs - Bottom ash and mixed ashes

Country	Type of incinerator	Year/date of measurement	Specification	Type of value (mean, med, max, min etc.)	Measured level in ng/kg (I-TEQ) of dry weight	Source of information
Thailand	MWI	1997 - 2001	bottom ash		10	9
Thailand	MWI	1997 - 2001	bottom ash		5	9
Thailand	MWI	1997 - 2001	bottom ash		6	9
Thailand	Medical waste incinerator	1997 - 2001	mixed bottom ash		1410-2300	10
Thailand	MWI	1997 - 2001	bottom ash	average conc.	7	10
Thailand	MWI	1997 - 2001	bottom ash	average conc.	8*	10
Thailand	Medical waste incinerator	1997 - 2001	mixed bottom ash	average conc.	1390	10
Thailand	Medical waste incinerator	1997 - 2001	mixed bottom ash	average conc.	1980*	10
Russia _ Moscow	MWI	1998	bottom ash/slag		30-55	21
Czech Republic – Liberec	MWI	2000	bottom ash/slag		4,37	27
Czech Republic – Ostrava	Haz. waste incinerator	2000	furnace slag		0.16-0.17	18
Czech Republic – Ostrava	Haz. waste incinerator	2000	furnace slag		2.9-3.6	18
UK – Bolton	waste incinerator	2001	bottom ash		1,6	3
UK - England and Wales	MWI	2001	bottom ash	range	0.64-23 (150)	5
Sweden	waste incinerators	1999	bottom ash/slag	average conc.	13.5-27	20
UK – Shefield	MWI	2001	bottom ash/slag	max. levels	122, 150	5
Thailand	Crematory	1997 - 2001	composite ash	individual sample	44	10
Czech Republic – Liberec	MWI	2000	mixed fly ash/bottom ash	individual sample	213,6	6
Czech Republic – Liberec	MWI	2000	mixed fly ash/bottom ash	individual sample	62	27

Table 3: PCDD/Fs - Waste water treatment sludge + other residues

Country	Type of incinerator	Year/date of measurement	Specification	Type of value (mean, med, max, min etc.)	Measured level in ng/kg (I-TEQ) of dry weight	Source of information
Thailand	Medical waste incinerator	between 1997 - 2001	sludge from the wastewater treatment		517-708	10
Thailand	Brass smelter	between 1997 - 2001	wastewater treatment sludge	average conc.	8625	10
Thailand	Brass smelter	between 1997 - 2001	wastewater treatment sludge	average conc.	9168*	10
Thailand	Medical waste incinerator	between 1997 - 2001	mixed flyash sludge	average conc.	629	10
Thailand	Medical waste incinerator	between 1997 - 2001	mixed flyash sludge	average conc.	703*	10
Thailand	Brass smelter	between 1997 - 2001	wastewater treatment sludge	range	8567-8683	10

Table 4: Other POPs measurements in different residues

Country	Measured chemical	Type of incinerator	Year/date of measurement	Specification	Type of value (mean, med, max, min etc.)	Measured level in ng/kg (I-TEQ) of dry weight	Source of information
Germany	PCB (ng WHO-TEQ/kg)	MWI	1997	fly ash	range	10-640	26
Germany	EROD (ng TEQ/kg)	MWI	1997	fly ash	range	660-49970	26
Japan	PCN	small scale incinerators and MWI	1998	fly ash	range	740-610000	11
Taiwan	Coplanar PCB (ng I-TEQ/kg)	MSW, 450 t/24 hours, dry scrubber + fabric filter	1998	fly ash	range	61.06-405.54	14
Taiwan	Coplanar PCB (ng I-TEQ/kg)	MSW, 75 t/24 hours, semidry scrubber + fabric filter	1998	fly ash		2942,44	14
Taiwan	Coplanar PCB (ng I-TEQ/kg)	MSW, 30 t/16 hours, semidry scrubber + ESP	1998	fly ash		2983,42	14
Taiwan	Coplanar PCB (ng I-TEQ/kg)	Medical waste incin., 3.6 t/8 hours, venturi wet scrubber	1998	fly ash		590,85	14
Taiwan	Total I-TEQ	MSW, 450 t/24 hours, dry scrubber + fabric filter	1998	fly ash	range	320-2932	14
Taiwan	Total I-TEQ	MSW, 75 t/24 hours, semidry scrubber + fabric filter	1998	fly ash		26737	14
Taiwan	Total I-TEQ	MSW, 30 t/16 hours, semidry scrubber + ESP	1998	fly ash		31900	14
Taiwan	Total I-TEQ	Medical waste incin., 3.6 t/8 hours, venturi wet scrubber	1998	fly ash		13857	14
Taiwan	Total I-TEQ	Electrical power plant	1998	fly ash		605	14
Taiwan	Total I-TEQ	Electrical power plant	1998	fly ash		63	14
UK	PCB	Waste incinerators	1996	bottom ash	range	less than 1000-8900	8
UK	PCB	Waste incinerators	1996	fly ash	range	less than 1000-23000	8

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Annex 3: Analytical results for individual samples taken in Izmit Hazardous Waste Incinerator (Turkey) by Greenpeace Research Laboratories

Sample Number: MI0064

REFERENCE NUMBER: TU001

SAMPLE TYPE: INCINERATOR BOTTOM ASH

Location: Kocaeli, Izmit, Turkey

Sampling Date: 05.04.00

Sample Information: Sample collected from slag/bottom ash commercial rotary kiln slagging plant type, Izmit Solaklar Koyu Mevkii waste incinerator.

ORGANIC ANALYTICAL RESULTS

Analysis method: GC/MS screen

Number of compounds isolated: 60

Compounds identified to better than 90%:

1,1'-Biphenyl, 2,2',3,4,4',5'-hexachloro- (PCB-138)	SIM only
1,1'-Biphenyl, 2,2',4,4',5,5'-hexachloro- (PCB-153)	SIM only
1H-Indene, 2,3-dihydro-	
Benzene, 1,2,3,5-tetramethyl-	
Benzene, 1,2,3-trimethyl-	
Benzene, 1,2,4-trimethyl-	
Benzene, 1,2-dimethyl-	
Benzene, 1,3,5-trimethyl-	
Benzene, 1,3-diethyl-	
Benzene, 1,4-dichloro-	SIM only
Benzene, 1-ethyl-2-methyl-	
Benzene, 1-ethyl-3,5-dimethyl-	
Benzene, 1-methyl-2-(1-methylethyl)-	
Benzene, 1-methyl-4-(1-methylethyl)-	
Benzene, 2-ethyl-1,3-dimethyl-	
Benzene, 2-ethyl-2,3-dimethyl-	
Benzene, propyl-	
Bicyclo[4.2.0]octa-1,3,5-triene	
Cycloeicosane	
Diphenylmethylene-cyclopropane	
Eicosane	
Heneicosane	
Heptacosane	
Naphthalene	
Naphthalene, 1,3-dimethyl-	
Naphthalene, 1,5-dimethyl-	

Naphthalene, 1,6-dimethyl-
Naphthalene, 1-methyl-
Naphthalene, 2,3,6-trimethyl-
Naphthalene, 2-methyl-
Phenanthrene, 4-methyl-
Phenol, 3-methyl- SIM only

Compounds tentatively identified:

1-Octadecene
1-p-Menthen-8-yl acetate
28-nor-17beta(h)-Hopane
Benzene, (1-methylpropyl)-
Benzene, 1,2,3,4-tetramethyl-
Benzene, 1-ethyl-2,3-dimethyl-
Benzene, 1-ethyl-3-methyl-
Benzene, 1-methyl-2-propyl-
Benzene, isopropyl-
Decane, 2-methyl-
Decane, 2-methyl-
Docosane
Eicosane, 9-octyl-
Heptadecane
Heptane, 2,6-dimethyl-
Hexadecane
Isoquinoline, 1,2,3,4-tetrahydro-
Octadecanoic acid, 2-[(1-oxohexadecyl)oxy]ethyl ester
Pentadecane, 2-methyl-
Tetradecane
Tricosane

Sample Number: MI0065

REFERENCE NUMBER: TU002

SAMPLE TYPE: INCINERATOR ASH (ESP)

Location: Kocaeli, Izmit, Turkey

Sampling Date: 05.04.00

Sample Information: Sample collected from electrostatic precipitator, Izmit Solaklar Koyu Mevkii waste incinerator.

ORGANIC ANALYTICAL RESULTS

Analysis method: GC/MS screen

Number of compounds isolated: 13

Compounds identified to better than 90%:

1,1'-Biphenyl, 2,2',3,4,4',5'-hexachloro- (PCB-138) SIM only
1,1'-Biphenyl, 2,2',4,4',5,5'-hexachloro- (PCB-153) SIM only

Compounds tentatively identified:

5-Eicosene, (E)-
5-Undecanone, 2-methyl-
6H-Purin-6-one, 1,7-dihydro-
Hydroxylamine, O-decyl-
Nonadecane
Octadecane

Sample Number: MI0067

REFERENCE NUMBER: TU004

SAMPLE TYPE: ECONOMISER ASH

Location: Kocaeli, Izmit, Turkey

Sampling Date: 05.04.00

Sample Information: Sample collected from incinerator heat exchanger, Izmit Solaklar Koyo Mevkii waste incinerator.

ORGANIC ANALYTICAL RESULTS

Analysis method: GC/MS screen

Number of compounds isolated: 12

Compounds identified to better than 90%:

1,1'-Biphenyl, 2,2',3,4,4',5'-hexachloro- (PCB-138) SIM only
1,1'-Biphenyl, 2,2',4,4',5,5'-hexachloro- (PCB-153) SIM only
Benzene, 1,4-dichloro-

Compounds tentatively identified:

Octadecane, 3-ethyl-5-(2-ethylbutyl)-

Abbreviations:

AhR - aryl hydrocarbon receptor

APC - Air pollution control system.

APCR - Air pollution control residues including all types of fly ashes, sorbalite etc.

BAT - Best Available Techniques, term used according to the Stockholm Convention

BEP - Best Environmental Practices, term used according to the Stockholm Convention

COP - Conference of the Parties, meeting of nations that have signed and ratified an international convention (here used for the Conference of the Parties to the Stockholm Convention

DHM - dissolved humic matter

EIA - Environmental Impact Assessment

EOCl - extractable organic chlorinated compounds

EOXs - extractable organic halogens

HCB - hexachlorobenzene

HR-GC/MS - high resolution gas chromatography, mass spectroscopy, analytical method to detect dioxins/furans

HpCDD - heptachlorodibenzodioxins; dioxin with seven chlorine atoms

HpCDF - heptachlorodibenzofurans; furan with seven chlorine atoms

HWI - hazardous waste incinerator

HxCDD - hexachlorodibenzodioxins; dioxin with six chlorine atoms

HxCDF - hexachlorodibenzofurans; Furan with six chlorine atoms

IPEN - International POPs Elimination Network, international network of NGOs (http://www.ipen.org)

IPPC - Integrated Pollution Prevention Control

I-TEQ - International Toxicity Equivalents; summary measure of toxic dioxins and furans that does not include dioxin-like PCBs, broadly similar to WHO-TEQ, but not the same

IWMI - Integrated Waste Management Inc.

mg/kg - milligram (10^{-3} g) per kilogram; equivalent to a teaspoon of salt in a bathtub

LAS - Linear Alkylbenzene Sulfonate

LRTAP - Long Range Transboundary Air Pollution (short name of specific international convention)

MSW - municipal solid waste

MWI - municipal waste incinerator (and/or incineration in some context)

MSWI - municipal solid waste incinerator (and/or incineration in some context)

ng/kg - nanogram (10^{-9} g) per kilogram, equivalent to a teaspoon of salt in a small lake, this is the same as pg/g

NGOs - non-governmental organizations

OCDD - octachlorodibenzodioxins, dioxin with eight chlorine atoms

OCDF - octachlorodibenzofuran, furan with eight chlorine atoms

PAHs - polyaromatic hydrocarbons

PBCDD/Fs - polybromochlorodibenzodioxins and polybromochlordibenzofurans

PBDD/Fs - polybromodibenzodioxins and polybromodibenzofurans

PBDEs - polybrominated diphenylethers

PCBs - polychlorinated biphenyls

PCDD/Fs - polychlorinated dibenzodioxins/polychlorinated dibenzofurans

PCDTs - polychlorodibenzothiophenes, the sulfur analogues of the PCDFs

PCNs - polychlorinated naphthalens

PeCDD - pentachlorodibenzodioxin, dioxin with five chlorine atoms

PeCDF - pentachlorodibenzofuran, furan with five chlorine atoms

POPs - persistent organic pollutants

RDF - refuse derived fuel

TCDD - tetrachlorodibenzodioxin, dioxin with four chlorine atoms

TCDF - tetrachlorodibenzofuran, furan with four chlorine atoms

TEQ - Toxicity equivalents

UNEP - United Nations Environment Programme

U-POPs - unintentionally produced POPs

WG - working group

WHO-TEQ - World Health Organisation Toxicity Equivalents, summary measure of toxicity that includes dioxins, furans, and dioxin-like PCBs; broadly similar to I-TEQ, but not same

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Wollondilly Shire Council

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RURAL LIVING

Our Reference: [redacted]

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22/08/2022

To Whom It May Concern,

PUBLIC EXHIBITION - WATER SHARING PLAN FOR THE GREATER METROPOLITAN REGION GROUNDWATER SOURCES AND WATER SHARING PLAN FOR THE GREATER METROPOLITAN REGION UNREGULATED RIVER WATER SOURCES

Thank you for the opportunity to provide feedback on the draft Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources and Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources (Water Sharing Plans) currently on public exhibition.

Measures to protect water sources (surface and groundwater) and manage water and agriculture are of critical importance for the Wollondilly Community. The exhibited draft Water Sharing Plans have relevance to Council's Integrated Water Management Policy, Strategy and Water Sensitive Urban Design (WSUD Guidelines) as well as its Rural Lands Strategy. It should be noted that most of the Wollondilly Shire falls within the Nepean Management Zone 2 and the combined management and protection of the Nepean River would be greatly enhanced by the introduction of a Nepean River Catchment Authority

(i) Issues associated with potential impacts to water sources

Council's Integrated Water Management Policy, Strategy and WSUD Guidelines approaches water management as a whole including the relationships between stormwater, waste water and potable water. The Water Sharing Plan consequently needs to show linkages and relationships to wider water management plans including monitoring programs to clearly show how they fit within the wider sustainable management of water.

The main focus of Council's Integrated Water Management Policy, Strategy and WSUD Guidelines is to drive smarter water management outcomes including:

- protection of the waterways and riparian habitats

- increasing community liveability
- supporting greener neighbourhoods
- supporting recreation and amenity
- supporting local biodiversity
- supporting water conservation
- supporting agriculture and other local economies
- supporting water reuse and recycling
- improving climate resilience including minimising heat island effect and flood management

Council considers the above principles as fundamental for inclusion in any water management plan. For example, it does not appear as if social values such as maintaining the swim ability of waterways is included in the risk assessments for the Water Sharing Plans.

Recent water balance modelling undertaken by council shows a clear surplus of water between stormwater and wastewater therefore, recycling wastewater has also been a key focus, to ensure better utilisation. While council does acknowledge the potential increase in harvestable rights for landholders, council would prefer a more rigorous overview in the supply of treated wastewater to landholders and industry as this would be a much more reliable and sustainable water source which would lead to a more resilient and prosperous long-term local economy.

Council has raised the issue of and expressed shortcomings in the modelling and assessment of potential impacts of longwall mining operations on groundwater and interconnecting surface waters in the Wollondilly LGA. The Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources in this regard is requested to also consider implications of water loss from groundwaters as part of mining operations. Monitoring of aquifers (including groundwater dependant ecology) and waterways should also be undertaken to help review impacts of the Water Sharing Plans over the next 10-year period.

Council further requests that adequate resources are provided for compliance/support to ensure users are extracting/water harvesting responsibly to accompany the Water Sharing Plans. Support should also be made available to help landholders and industry refine practices to minimise overall water use or link to more sustainable water supplies such as recycled wastewater.

(ii) Potential implications to agricultural activities

The consultation undertaken as part of Council' Rural Lands Strategy identified the following:

- Agricultural producers revealed that water availability was one of the main barriers to expanding production.
- The agricultural capability of land adjoining the Nepean River increases with the potential for surface water diversion and crop irrigation. The availability of irrigation water opens up a wider range of agricultural types including higher value horticultural commodities such as turf and fruit on better soils. Without irrigation, horticultural crops will be limited to low water using crops such as grapes or olives.
- Over extraction, particularly from surface water is one of the biggest water related problems in the Shire.
- Secure access to water will be a key driver of growth in horticultural production in Wollondilly.

The Rural Lands Strategy also identified that the highest quality agricultural land in the Shire is located within the Nepean River Floodplain. On that basis, perhaps the Groundwater Plan could give greater priority to those lands which are within the floodplain but may not be able to undertake surface water extraction as a means of encouraging production activities.

Please contact Council's Acting Team Leader Environmental Services, [redacted] or via e-mail [redacted] for any enquiries regarding this correspondence.

Yours faithfully

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