



Forensic Data Analysis for illegal waste trafficking

Date: 20 august 2020

Work Package: 3

Deliverable: 3.2



The WasteForce project is funded by the European Union's
Internal Security Fund – Police (ISFP/2017/AG/ENV/821345)

DETECTING AND DISRUPTING ILLEGAL TRADE AND MANAGEMENT OF WASTE BY DEVELOPING TOOLS FOR ENFORCEMENT, FORENSICS AND CAPACITY BUILDING

FORENSICS AND TOOLS

FORENSIC DATA ANALYSIS FOR ILLEGAL WASTE TRAFFICKING

FORENSIC TOOL FOR DATA COLLECTION, RETRIEVAL AND ANALYSIS

Project	Deterring and disrupting illegal trade and management of Waste by developing Tools for Enforcement, Forensics and Capacity Building
Acronym	WasteForce
Work Package:	WP3 Forensics and Tools
Work Package Leader:	United Nations University
Deliverable:	3.2
Deliverable Leader:	Netherlands Forensics Institute, Environmental Forensics
Date of submission:	20 August 2020
Version:	1.0
This project has been funded by the European Commission Directorate-General Migration and Home Affairs under Grant Agreement Number ISFP-2017-AG-ENV.	

NOTICE

The contents of this document are the copyright of the WasteForce consortium and shall not be copied in whole, in part, or otherwise reproduced (whether by photographic, reprographic or any other method), and the contents thereof shall not be divulged to any other person or organization without prior written permission. Such consent is hereby automatically given to all members who have entered the WasteForce Consortium Agreement, dated 01 December 2018, and to the European Commission to use and disseminate this information.

The information and content of this report is the sole responsibility of the WasteForce Consortium members and does not necessarily represent the views expressed by the European Commission or its services. While the information contained in the documents and webpages of the project is believed to be accurate, the authors(s) or any other participant in the WasteForce consortium make no warranty of any kind with regard to this material.

AUTHOR(S)

Marion Stelling & Fred Bakker

Environmental Forensics, Netherlands Forensic Institute (NFI), The Hague

ACKNOWLEDGEMENTS

The knowledge and expertise of the NFI Forensic Big Data Analysis (FBDA) team did made this research possible. We thank Nivea de Carvalho Ferreira, Niels Prins, Bart Broere, Timo Matzen, Rolf Ypma, Simone Ariens for their expertise and work in the development of a Proof of Concept tool for *Environmental Forensic Data Analysis*.

Executive summary

The WasteForce project aims to boost the operational activities and capacities of authorities involved in the fight against illegal trade and management of waste. In WasteForce project deliverable 3.2. *Forensic Data Analysis* a prototype of a forensic tool for data retrieval and analysis is developed. Forensic research performed in criminal cases dealing with transnational waste trafficking is multidisciplinary, generating large amounts of data from different types of wastes, contaminants, production processes and recovery operations. The combination of an *Environmental Forensics Database* and the opportunity to use the knowledge and expertise on forensic data analysis by the NFI *Forensic Big Data Analysis* (FBDA) research group created the opportunity for the development of a Proof of Concept tool for environmental forensic data analysis. This tool provides the following options:

- An overview of the number of cases per year, as well as chemicals and incidents.
- The combination of top 5 chemicals and/or incidents.
- Free combinations of chemicals or incidents.
- The possibility to search for expert reports based on free text.

The prototype already highly improves access to historic data to be used in future casework and assists to obtain intelligence information. Examples of environmental forensic data analysis on different aspects of illegal waste trafficking demonstrate that a focus on environmental forensics broadens knowledge on waste crime. Restrictions of the Proof of Concept tool are mainly related to the limitations of the *Environmental Forensics Database*. An important limitation is for example that the database only contains Dutch criminal cases in which technical research was performed by the Netherlands Forensics Institute (NFI). In general, a limited or biased database is an important pitfall in any data analysis. Smart linkage to other information sources might overcome this and improve the tool in the future.

Table of content

- Executive summary 3
- Table of content..... 4
- List of figures, photos and tables 5
- Aim and objectives 6
- 1. Introduction 7
 - 1.1 Environmental Forensics Database 8
- 2. Development of a Proof of Concept tool for environmental forensic data analysis 9
 - 2.1 Description of the software technique 10
 - 2.2 Description of the user interface 11
- 3. Forensic Data Analysis for illegal transnational waste trafficking 15
 - 3.1 Types of Waste 16
 - 3.2 Illegal activities 18
 - 3.3 Waste movements..... 19
 - 3.4 Type of companies 20
 - 3.5 Trigger for investigations 21
 - 3.6 Results forensics 22
- 4. Focus on materials and chemicals in relation to illegal waste trafficking 24
- 5. Experiences and lessons learned 27
- List of abbreviations and definitions..... 28
- References..... 30

List of figures, photos and tables

Figure 1 Data pipeline 10

Figure 2 Overview of the techniques used to create the Proof of Concept tool 10

Figure 3 WasteForce casus dashboard 12

Figure 4 Dashboard Top 5 combinations 13

Figure 5 Dashboard free selection of combinations 14

Figure 6 Types of wastes in the Environmental Forensics Database. Illegal or counterfeit pesticides should be considered as products 16

Figure 7 Activities related to illegal waste trafficking 18

Figure 8 Illegal waste movements between the Netherlands and other countries 19

Figure 9 Type of companies 20

Figure 10 Trigger for investigation 21

Figure 11 Outcomes forensics 22

Figure 12 Key findings forensic data analysis for illegal waste trafficking 23

Photo 1 Transfer of soil with visible contamination from Swiss into the Netherlands (Photo NFI) 6

Photo 2 Illegal export of hazardous WEEE with brominated flame retardants (photo NFI). Detection has taken place with a mobile XRF (X-ray fluorescence) 7

Photo 3 Export of plastic containers with residues of hazardous materials from the Netherlands to Ghana (Photo NFI) 9

Photo 4 Visible contamination of aluminium scrap. The material was unduly being exported from the Netherlands to China as Green listed (not mixed material) under the Waste Shipment Regulation (WSR) (photo NFI) 15

Photo 5 Import into the Netherlands from Eastern Europe of old army filter canisters. Besides the common asbestos type chrysotile the filters also contain the rarer richterite and winchite fibres (picture SEM (Scanning Electron Microscope) on the right). The latter are asbestos like fibres but not regulated (Photos: NFI) 24

Photo 6 Label of Omite, sold via the internet as an insecticide containing elevated levels of the active substance propargite (Photo: NFI) 26

Table 1 Active substances of pesticides encountered in illegal trade 25

Aim and objectives

In Forensic Data Analysis for illegal waste trafficking a prototype of a forensic tool for data collection, retrieval and analysis is developed. The tool should improve access to historic data to be used in future casework and can assist to obtain intelligence information. It is expected that the data generated by forensic research contains information about vulnerability of specific waste streams for criminal activities, how it occurs, and how this can be detected.



Photo 1 Transfer of soil with visible contamination from Swiss into the Netherlands (Photo NFI)

1. Introduction

The WasteForce project aims to boost the operational activities and capacities of authorities involved in the fight against illegal trade and management of waste. In WasteForce work package 3 “Forensics and tools” a Proof of Concept tool for Environmental Forensic Data Analysis is developed.

Waste crime has many different manifestations with a strong connection to economic activities in different regions and countries. Waste types and ways to conceal infringements are variable driving the need for different methods to detect waste crime and tools to handle the information collected. As a consequence, a lot of data have been and are being generated on waste crime (EEB, 2020) (Meneghini, Favarin, Andreatta, & Savona, 2017) (Suvantola & Kankaanranta, 2017). The complexity and diversity of the digital material collected grows and more advanced techniques are needed to keep up with this evolving process.



Photo 2 Illegal export of hazardous WEEE with brominated flame retardants (photo NFI). Detection has taken place with a mobile XRF (X-ray fluorescence)

Within the Netherlands Forensic Institute (NFI) Forensic Big Data Analysis (FBDA) provides advanced data analysis services to clients within the public order and security sector who wish to extract essential information from large quantities of digital data. Forensic Big Data Analysis' core activities include:

- *Text mining*
Deriving high-quality information from texts, including documents, spreadsheets, emails and digitalised paper documents. Text mining makes it possible to automatically identify, classify and summarise relevant information, which can then be searched and analysed faster and more effectively.

- *Data profiling*

Examining the data available in an existing data source, collecting statistics and information about that data, and identifying any patterns within it. Establishing a data profile makes it possible to classify data and potentially predict missing values or links.

- *Financial data analysis*

Analysing financial transactions so that flows of money become visible and can be traced. Although mainly used to trace fraud, these techniques can also be used (for example) to discover how intermediaries raise funds.

- *Social network analysis*

Revealing relationships between people and groups by studying how they are linked through telephone or email records, on the internet, or even in traffic patterns. In this way, it is possible to unmask someone using an alias or to reveal how criminal groups work together.

1.1 Environmental Forensics Database

For the WasteForce project the focus will be on text mining and data profiling the existing NFI *Environmental Forensics Database*.

The *Environmental Forensic Database* holds information on technical research performed in more than thousand environmental criminal cases in the Netherlands over the past decades.

Information with respect to illegal waste trafficking is expected to be present among this information. The type of information is variable per case but information on the following topics might be present (not limitative):

- Case context information
- Type of infringements
- Information with respect to sampling procedures
- Type, properties and compositions of materials, descriptions of samples
- Photo's (environmental crime scenes, sampling procedures and materials sampled)
- Research methods and outcomes of technical research performed
- Types of suspected companies and stakeholders
- Descriptions of production processes
- Outcomes of calculations and mathematical models

An important limitation of the database is that it only holds information with respect to criminal environmental cases in which the NFI performed research. Another limitation is that the vast majority of the NFI cases is related to Dutch criminal cases. Other types of cases like administrative and civil cases and cases without a link to the Netherlands are not expected to be present in relevant numbers.

2. Development of a Proof of Concept tool for environmental forensic data analysis

Information and data in illegal waste trafficking tend to expand to amounts that are difficult to handle. The NFI Environmental Forensics research group holds a database with technical information on environmental criminal cases. Combining the expertise of Forensic Big Data Analysis team with the Environmental Forensics database created the opportunity for the development of a prototype of a software tool for data analysis.



Photo 3 Export of plastic containers with residues of hazardous materials from the Netherlands to Ghana (Photo NFI)

FBDA has been improving their methodologies for digital forensics over the years. Their knowledge and expertise were used to create a custom-made tool for *Environmental Forensic Data Analysis*. Information within the *Environmental Forensics Database* originates from all kind of different sources in different file formats. While this information can and should be combined in meaningful ways, it is difficult to obtain an integrated view on the output of the different information sources. For the design of the Proof of

Concept tool for *Environmental Forensic Data Analysis* the following criteria were set:

- It must be able to deal with different types of information and file types
- It must be flexible, allowing a wide range of queries
- It must be future proof, meaning it must have an opportunity to update the database with new cases

2.1 Description of the software technique

A first step in data analysis is processing the available digital information.

All case files in the *Environmental Forensics database* over the period 2000-2020 were processed. Subsequently, documents were filtered and relevant data were extracted from the document by

means of parsing. The structure of the data pipeline is given in Figure 1. Figure 2 shows an overview of the techniques used.

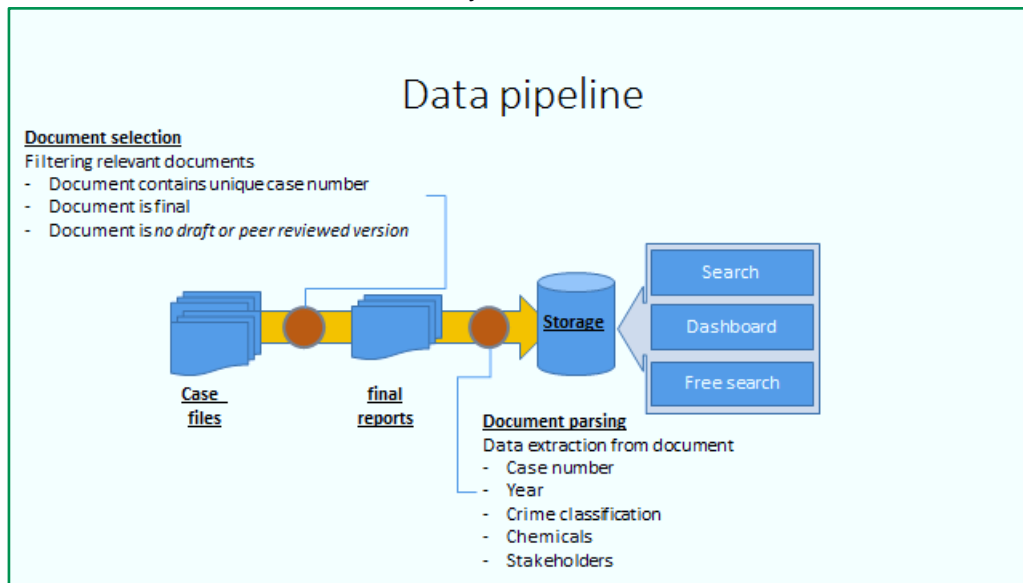


Figure 1 Data pipeline

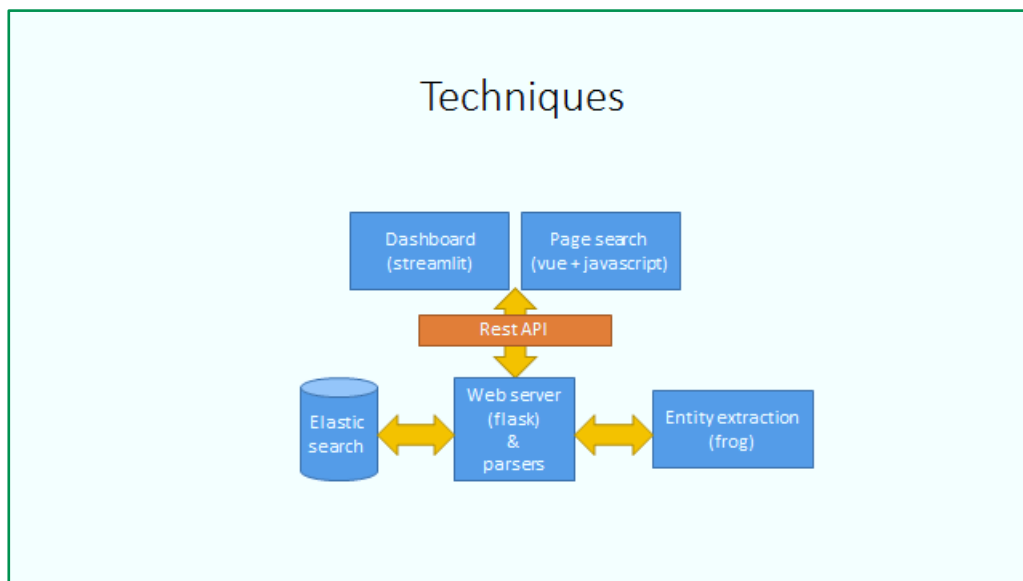


Figure 2 Overview of the techniques used to create the Proof of Concept tool

2.2 Description of the user interface

To facilitate data analysis a dashboard has been created. The dashboard has the opportunity to display different statistics such as the number of cases over the years, top 5 combinations of chemicals and incidents, as well as free combinations of those and finally it provides the opportunity for free text searches among documents.

Numbers

The user interface consists of the aggregation of numbers of total or specific cases or chemicals a year. It displays the following aspects (see also Figure 3):

- Total number of cases per year
- Total number of a specific chemical substance a year
- Total number of cases with a specific type of incident or illegal activity (fraud, dumping, etc.)

The visualisation of numbers allows the detection of trends in historic data. The lower part Figure 3 for example shows (in orange) the number of times the pesticide

fipronil showed up in Dutch criminal cases. Fipronil is an authorised broad-spectrum insecticide used as a pest control product, as well as an ingredient in flea control products for pets. It is however banned by the EU for use on animals meant for human consumption. In 2017 there has been an incident consisting of large amounts of chicken eggs being contaminated with fipronil (European Commission, December 2017). The numbers in Figure 3 indicate that fipronil already showed up in criminal cases since 2012.

Figure 3 also illustrates the continuing need for interpretation of the data. The blue line in figure should indicate the chemical DEF. DEF is short for the chemical tributylphos (tributylphosphorotrithioate with chemical abstract (CAS) number 784888). Closer inspection of the underlying information however learned that the numbers are distorted by the word “def” (short for definitive or definition) in the expert reports.

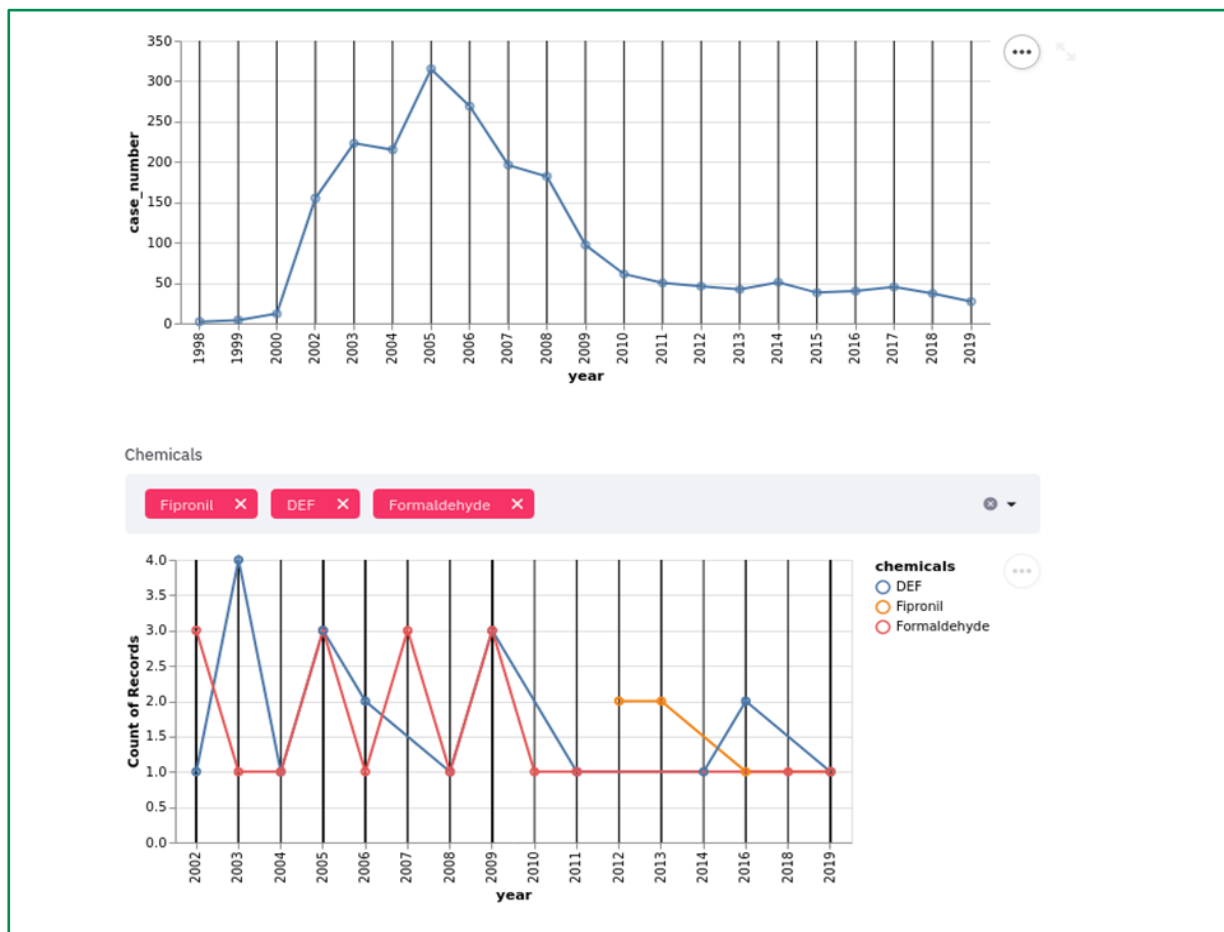


Figure 3 WasteForce casus dashboard

Top 5 combinations

Figure 4 shows the dashboard with Top 5 combinations. These are the most frequent occurring combinations (top 5) from the perspective of one specific substance or incident type. The dashboard displays the following combinations:

- Number of cases in which a substance (X) occurs in combination with other specific chemicals
- Number of cases in which a specific type of incident (Y) occurs in combination with the selected substance
- Number of cases in which incident type (Y) occurs in combination with other specific incidents

- Number of cases in which substance (X) occurs in combination with the specific selected type of incident

Combinations of chemicals give insight in the composition of wastes in relation to specific illegal activities. The upper part of Figure 4 shows, for example, that the chemical methylamine most frequently occurs in combination with ethanol, methanol and isopropanol. All of these chemicals are part of the wastes generated during the production of MDMA (3,4 methylene dioxymethamphetamine or ecstasy) and/or amphetamine. The illegal activity associated with this combination of chemicals is dumping. If the focus is placed on the activity “fraud” the most

frequently associated chemicals are glycerol and methanol and to a lesser extend benzophenone, dibenzofuran and ethanol. The glycerol, methanol and ethanol are all associated with biodiesel production (2009/28/EC, 23 April 2009). Fraud with ground materials used as feedstock for biodiesel production is well known (Human Environmental and

Transport Inspectorate (in Dutch), may 2019). In these cases, UCO (Used Cooking Oil) is for example replaced by unsustainable feedstock. The figures also show that the numbers are small, indicating the variable character of waste crime.

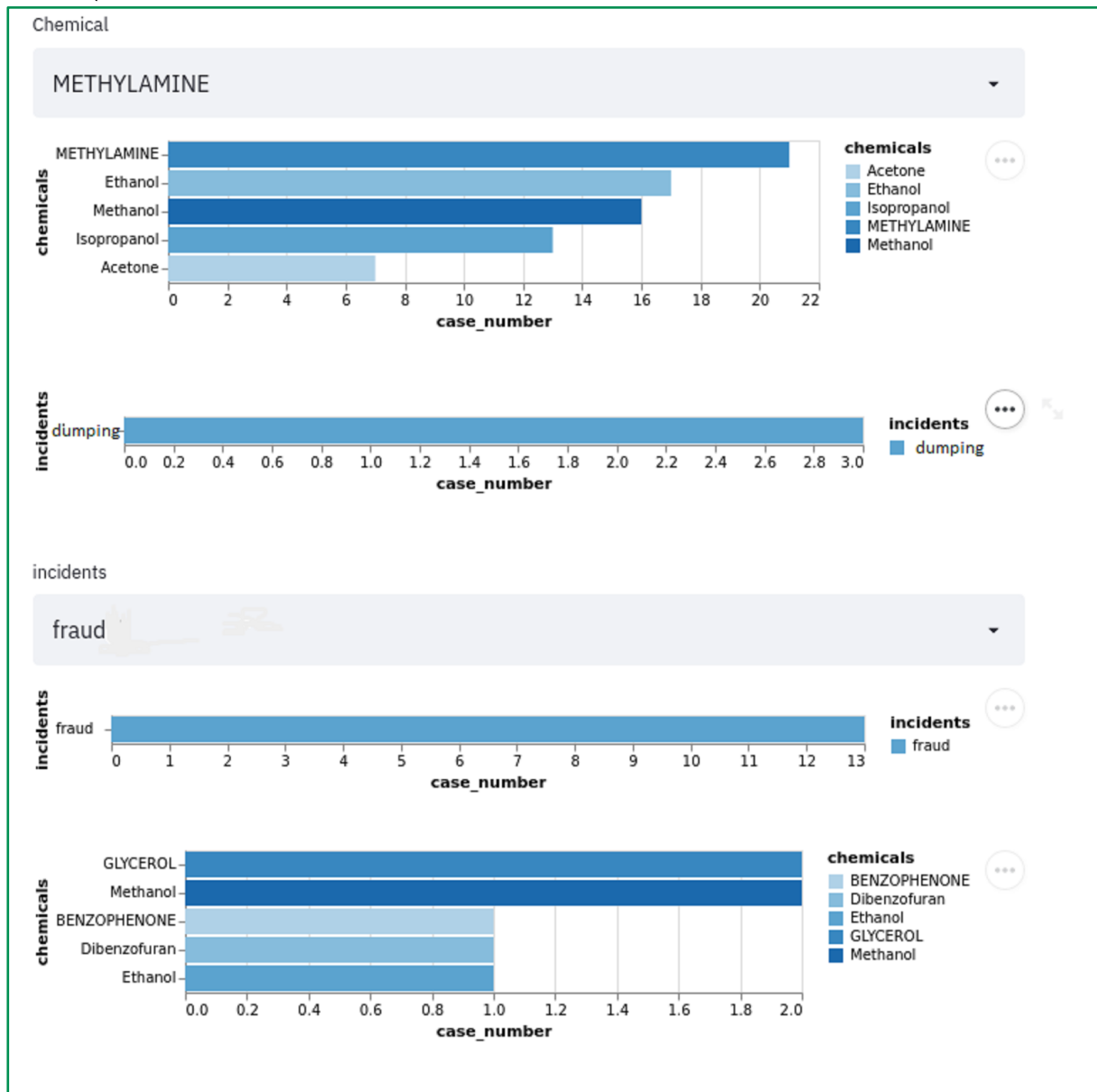


Figure 4 Dashboard Top 5 combinations

Combinations

Figure 5 shows the dashboard for the free selection of combinations. It displays the following options:

- Number of cases in which different chemicals occur in combination with the selected chemical
- Number of cases in which an incident occurs in combination with the selected chemical
- Number of cases in which other incidents occur in combination with the selected incident

- Number of cases in which substances occur in combination with the selected incident type

The upper part of figure 5 indicates the number times the chemical methanol occurs in illegal activities. The middle part figure 5 shows that methanol also occurs in combination with different kinds of pesticides, like flutolanil, carbendazim, imidacloprid and atrazine. This indicates that the chemical itself seems to be not specific. The mere presence of methanol alone may not be very informative.



Figure 5 Dashboard free selection of combinations

3. Forensic Data Analysis for illegal transnational waste trafficking

To illustrate the possibilities of the Concept for Proof tool for Environmental Forensic Data Analysis transnational illegal waste transports were used as a case study. Waste trafficking is interesting for data analysis since large amounts of information are involved, like documents, waste movements, waste types, illegal activities and types of companies involved. Improvement of the use of historic data can be used to identify patterns in future cases.



Photo 4 Visible contamination of aluminium scrap. The material was unduly being exported from the Netherlands to China as Green listed (not mixed material) under the Waste Shipment Regulation (WSR) (photo NFI)

Out of around 2150 environmental criminal cases, files related to illegal transnational trafficking were selected. The selection was generated by using the key words, WSR (Waste Shipment Regulation), export, import in the free search for expert reports option.

The retrieved case files were analysed in more detail. A further refinement was obtained by removing cases in which criminal investigation was terminated halfway and cases with a negative outcome. The remaining 44 case files consisting of illegal waste trafficking were used for detailed analysis. The focus was on the following information:

- Types of waste
- Illegal activities
- Waste movements
- Type of suspects (companies)
- Trigger for investigation
- Results forensics

Not in all case files all information was available. A limited number of cases consisted of products like illegal pesticides and mercury for illegal gold mining (one case) that were trafficked. The results of the data analysis are presented in the Figures 6 to 12.

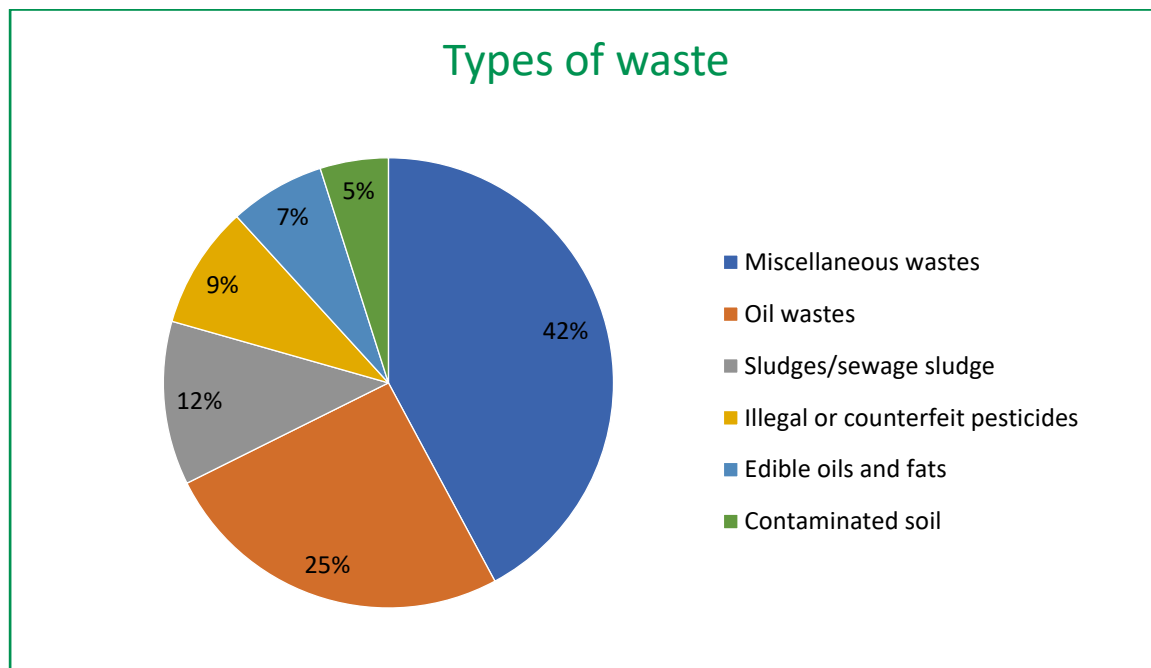


Figure 6 Types of wastes in the Environmental Forensics Database. Illegal or counterfeit pesticides should be considered as products

3.1 Types of Waste

Most criminal activities take place with different types of wastes; 42% of the case files ended up in the miscellaneous category. Most of these wastes like used papers, contaminated aluminium scrap and WEEE with brominated flame retardants occurred in the *Environmental Forensics Database* only once. A limited number of wastes types occurred multiple times. These were oil wastes¹, sludges /sewage sludge², illegal or counterfeit pesticides, edible oils and fats³ and contaminated soils⁴.

The information extracted from the *Environmental Forensics Database* deviates from data collected by the Dutch customs. Customs inspects annually thousands of containers that leave the Netherlands (Neve, 2013). The percentage of infringements is variable per waste type but is estimated to be 10% as an average. For contaminated soil in 30% of the inspection infringements are notified. WEEE, paper and plastics are the dominant waste materials for which infringements are notified by inspections (Neve, 2013).

¹ These wastes can have Basel Convention Codes A4060 or are in chapter 13 *Oil wastes and wastes of liquid fuels* of the European List of Waste (LoW) (EC No 1013/2006, 14 June 2006).

² These are a heterogeneous group of wastes that are for example in chapter 19 of the List of Waste (LoW).

³ Basel Convention code B3065 *Waste edible fats and oils of animal or vegetable origin* or List of Waste codes 20 01 25/ 20 01 26*. These wastes are also referred to as UCO (Used Cooking Oil).

⁴ These wastes are for example in the chapters 19 and 20 of the European List of Waste (LoW).

In the European market the wastes types mentioned are more or less like the Dutch customs results. Although European inspection results also show a large number of violations for metals (12%) and ELVs & car parts (9%), (SWEAP Project, 2020) (Olley, Ross, & O'Shea, Project Report 2014-2015).

In an international study led by Interpol Electronic waste was prevalent in illicit shipments, followed by metal waste and waste from car industry which mostly included used tyres (20%) in addition to vehicle components and oil—or a mixture of both e-waste and tyres (Interpol, December 2017).

Information collected during the WasteForce project (WasteForce, January 2018- January 2019) (WasteForce, September-November 2019) (WasteForce, March-may 2019) (WasteForce, June 2019-August 2018) (WasteForce, December -February 2020) indicates a dominant role for plastic waste (23% of the cases). E-waste was responsible for 10% of the violations. Other materials were quite miscellaneous, to be mentioned are ozone depleting substances (6% of the violations), household waste (4%) and unspecified hazardous waste in 5% of the cases.

In general, a substantial 13% amount of non-hazardous waste generated within the

European Market is suspected to disappear from the legal market (Meneghini, Favarin, Andreatta, & Savona, 2017). For the Netherlands, this figure is 0.3-2.9%. The same study mentioned that around 33% of the generated hazardous waste in the EU was not recorded as treated. The differences between the individual countries are quite large; for the Netherlands, the figure is 0.3-15%.

The differences between the outcomes in the cases extracted from the *Environmental Forensics Database* and other sources of information can be explained in two ways. First of all in the Netherlands only in a small number of infringements a criminal investigation is started. In the period 2008-2011 this happened in 15 cases (Neve, 2013). Secondly infringements detected by inspections are in most cases based on administrative and visual inspections (see also Figure 10). In most of these cases no additional forensic research is needed. The *Environmental Forensics Database* only holds cases in which forensic research was performed.

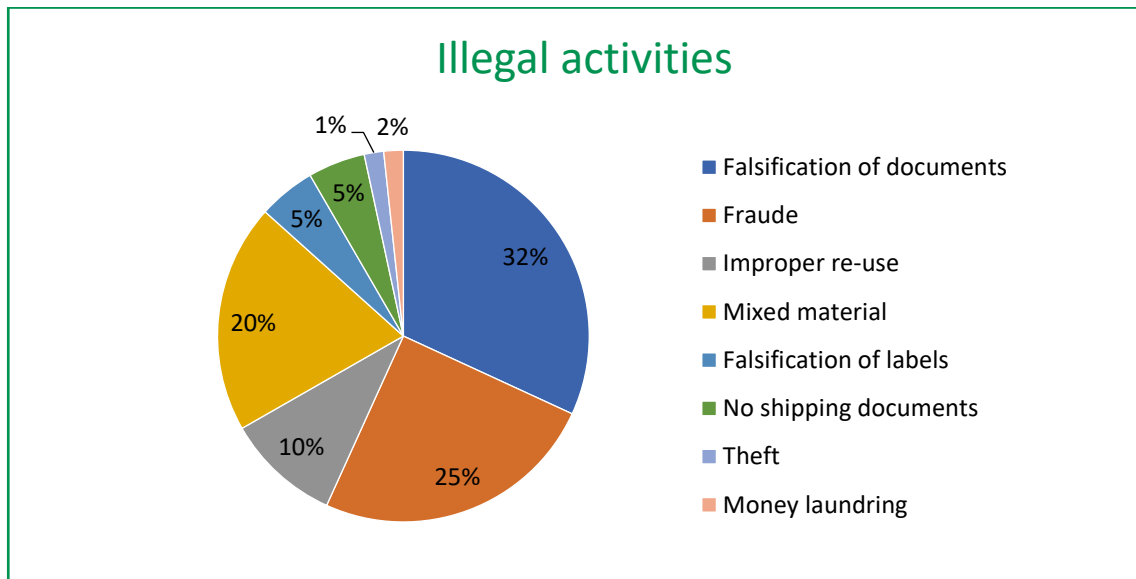


Figure 7 Activities related to illegal waste trafficking

3.2 Illegal activities

Figure 7 shows that the dominant illegal activities in the *Environmental Forensics database* are related to some kind of falsification, fraud, incorrect or missing documents.

This is in line with other information sources (Neve, 2013) (SWEAP Project, 2020) (Suvantola & Kankaanranta, 2017) (Interpol, December 2017) (Olley, Ross, & O'Shea, Project Report 2014-2015) (Suvantola & Kankaanranta, 2017). An important addition is that other information sources do mention quite a large number (22%) of material shipped that is subjected

to an export ban (SWEAP Project, 2020) (Interpol, December 2017). In the Interpol study in 50% of the cases no concealment method was used. In other cases, only unsophisticated concealment methods, such as rudimentary mixing or covering were used.

In most cases collected during the WasteForce project the modus operandi was unclear or not specified, although issues with documents are mentioned. Illegal internet trade was mentioned twice (WasteForce, March-may 2019) (WasteForce, June 2019-August 2018) (WasteForce, December -February 2020).

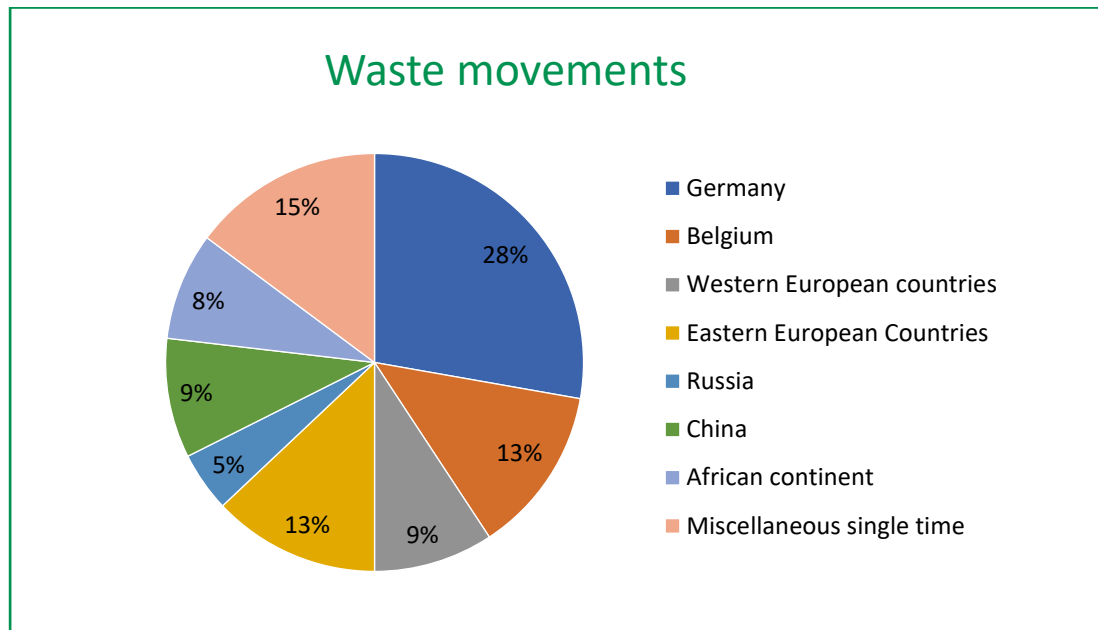


Figure 8 Illegal waste movements between the Netherlands and other countries

3.3 Waste movements

Figure 8 shows the outcomes with respect to the waste movements from and into the Netherlands. The majority of the illegal waste movements are between the neighbouring countries Germany and Belgium and other European countries.

This information is in line with the results from the SWEAP project (SWEAP Project, 2020), in which 51% of the violations noted concerned shipments within Europe.

A broader comparison of the above-mentioned findings with literature shows that if the focus is placed on a specific waste type the outcomes deviate. Identified routes for waste movements of paper, plastics and metals are from the Netherlands towards Asia (China) and WEEE is predominantly exported towards Africa (Neve, 2013).

Information collected during the WasteForce project confirms that the dominant route for waste is from EU to African and Asian countries. However, in 22% of the cases also movements within the EU are recorded. (WasteForce, January 2018- January 2019) (WasteForce, March-may 2019) (WasteForce, June 2019-August 2018) (WasteForce, September-November 2019) (WasteForce, December -February 2020).

In an Interpol study transcontinental flows accounted for the majority of transboundary movements with export from Europe to Africa being the most dominant. In this study intra-continental trafficking was less pronounced (Interpol, December 2017).

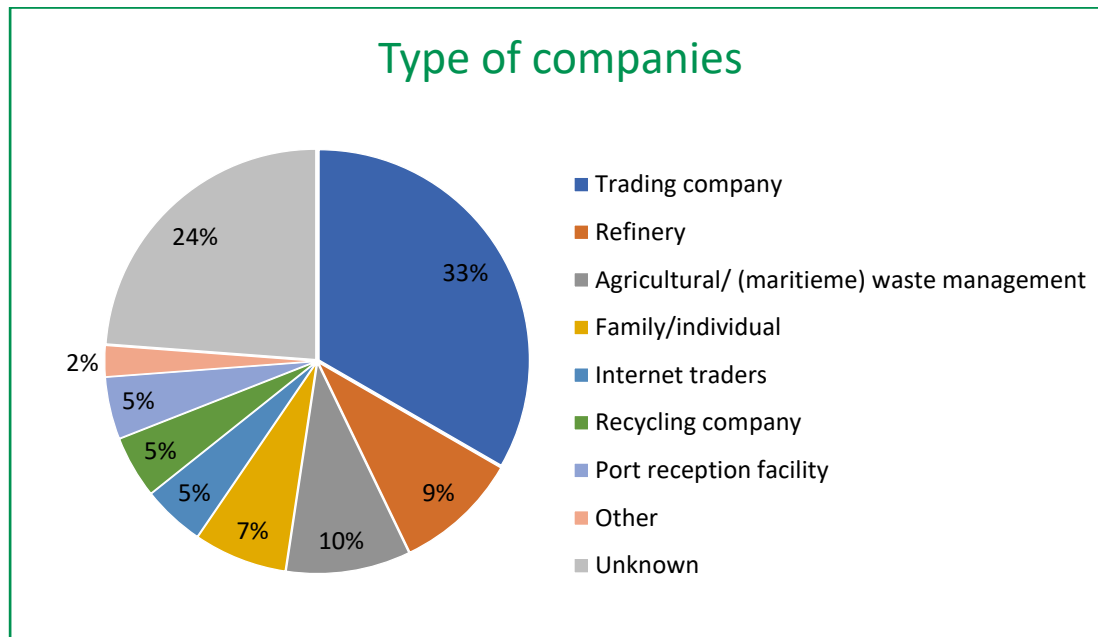


Figure 9 Type of companies

3.4 Type of companies

In the *Environmental Forensics Database*, the dominant suspects are trading companies (see Figure 9). It should be noted however that in a substantial number of cases (24%) information with respect to the suspects was lacking. The prominent role for professional traders in illicit waste trafficking is confirmed by other studies (Neve, 2013).

Other information collected in the WasteForce project indicates that in 73% of the cases companies are involved (WasteForce, January 2018- January 2019) (WasteForce, March-may 2019) (WasteForce, June 2019-August 2018) (WasteForce, September-November 2019) (WasteForce, December -February 2020).

Interpol on the other hand does mention a large number (44%) of individuals as offenders (Interpol, December 2017).

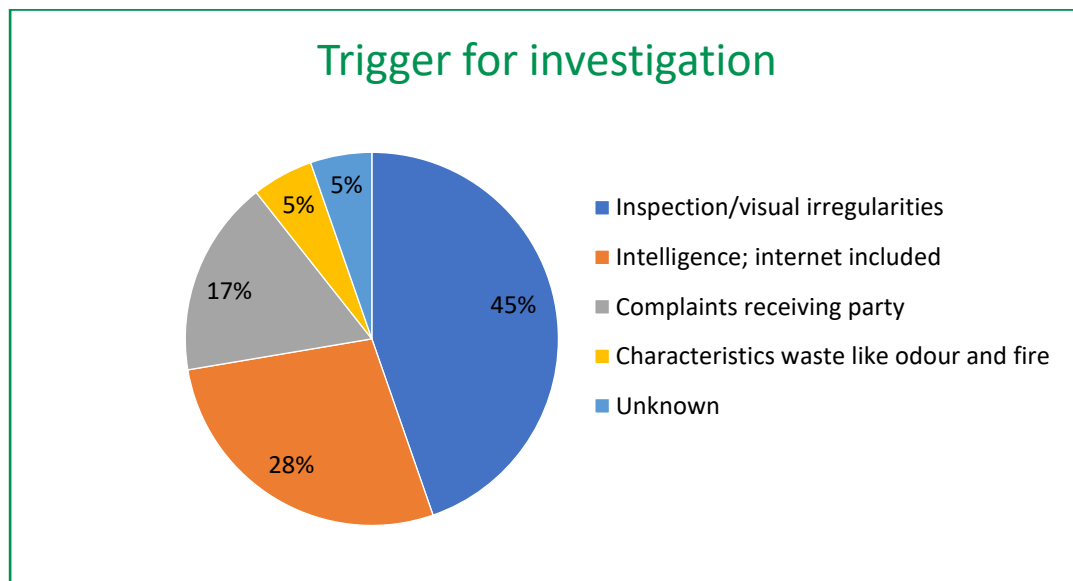


Figure 10 Trigger for investigation

3.5 Trigger for investigations

As shown in Figure 10 inspections have a prominent role in the detection of illegal waste trafficking.

General observation is that inspection seems to be the most important tool to detect illegal waste trafficking. During the SWEAP (Shipment of Waste Enforcement Actions) project (see <https://www.impel.eu/wp-content/uploads/2020/05/SWEAP-inspection-results-2018-2020-updated.pdf>) inspection results over the period 2018-March 2020 were collected from 28 countries across Europe. Their conclusion was that the violation rate is 22%. This is in line with other estimates (EEB, 2020) (Olley, Ross, & O'Shea, Project Report 2014-2015) (Interpol, December 2017).

It could be interesting to explore whether waste trafficking shows similarities to a topic like food fraud (Gussow, 2020). Conclusion for food fraud is that enforcement agencies are not able to detect all kinds of food fraud merely by performing routine compliance inspections; these explained only 10% of the food fraud detected. Other detection pathways seem to be very important here. A variety of information gathering strategies and some luck are required to find the full range of food fraud and offenders that may silently operate within and around the food industry. It is also concluded that the extent to which an enforcement agency invests in a specific detection pathway defines the pattern of crime it is likely to detect. Too much a focus on inspection alone may result in an over-focus on observable, less important fraud.

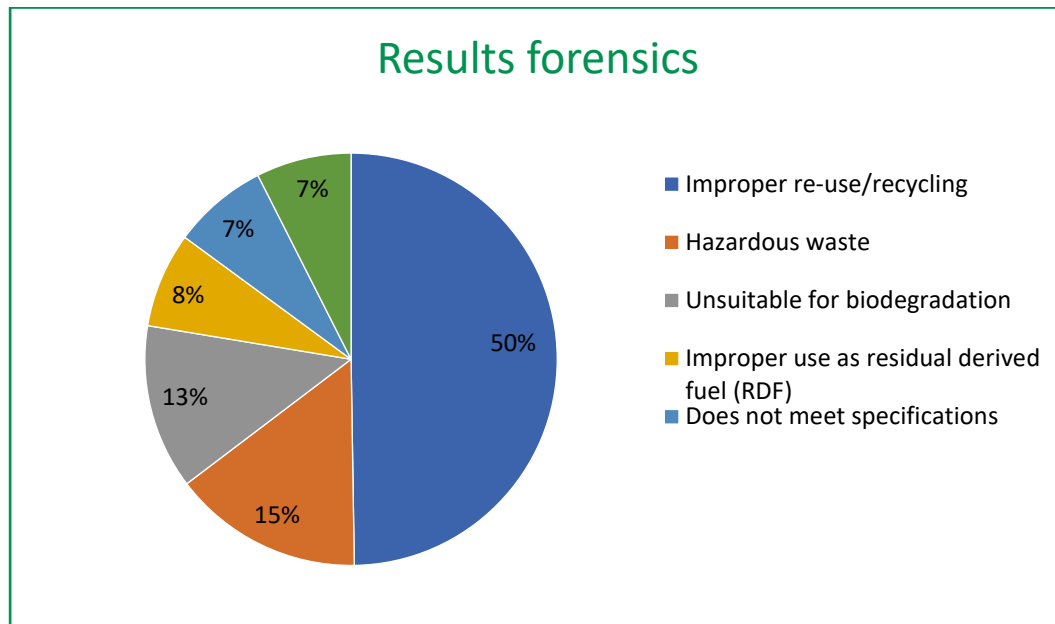


Figure 11 Outcomes forensics

3.6 Results forensics

Figure 11 shows the results with respect to forensics. Results are presented on headlines. Conclusions were based on the outcomes of different technical methods. Some more details with respect to the outcomes of forensic research in cases will be given in chapter 4. The results show that most of the trafficked wastes are re-used and recycled to some extent. In general the oil wastes are re-used as (bunker) fuel (see also (Buck de, 2011)), the sludges are used as feed stock for biodegradation processes (see (Saveyn & Eder, 2014)) and the edible oils and fats are used as feed stock for biodiesel production (see (2009/28/EC, 23 April 2009) (Dutch Emissions Authority, 24

August 2016) (Grinsven van, Kampman, & Scholten, June 2015) . The case files also mentioned different types of more unusual recycle options. The containers shown on photo 3 with hazardous materials for example were intended as water reservoirs in Ghana. The filter canisters shown on photo 5 can be re-used as decorative oil lamps. The outcome that wastes are trafficked to be recycled or re-used is in line with other Dutch information sources (Neve, 2013).

The overall outcomes of the forensic data analysis case study on illegal waste trafficking are summarized on headlines in Figure 12.

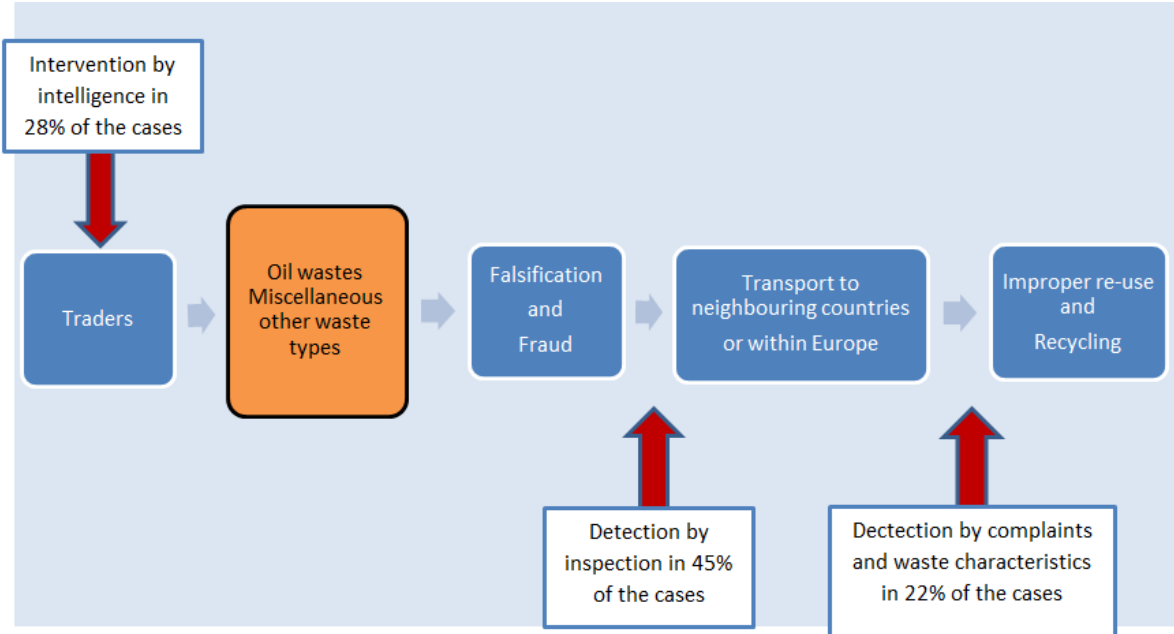


Figure 12 Key findings forensic data analysis for illegal waste trafficking

4. Focus on materials and chemicals in relation to illegal waste trafficking

Within the Environmental Forensics Database, the most relevant information is expected to be with respect to types of wastes, contaminants, and ways to detect contaminants in relation to improper re-use and recycling of wastes. Forensic research questions in waste crime investigations are variable. The fact that the Proof of Concept tool for Environmental Forensic Data Analysis allows flexible queries is of great advantage. Consequently, the data analysis is not limited to a set of predefined investigation patterns.



Photo 5 Import into the Netherlands from Eastern Europe of old army filter canisters. Besides the common asbestos type chrysotile the filters also contain the rarer richterite and winchite fibres (picture SEM (Scanning Electron Microscope) on the right). The latter are asbestos like fibres but not regulated (Photos: NFI)

To illustrate the possible benefits of a tool for forensics data analysis in illegal waste trafficking the outcome of different queries are presented.

Asbestos

One of the reoccurring dangerous substances in the Environmental Forensics database with respect to illegal trafficking is asbestos (around 10% of the cases involved asbestos). Types of wastes/materials involved were contaminated soil, blasting grit (see also <https://www.inspectorieszw.nl/topics/blast>

[ing-grit-containing-asbestos](#)) and filter canisters (see photo 5). In all these cases materials/wastes were imported into the Netherlands to be re-used.

Other examples of illegal trade in asbestos not offered for research at the NFI are ship-breaking (Court of Rotterdam, 2018), cosmetic products (talc) (Netherlands Food and Consumer Product Safety Authority, 2018) and soil contaminated with asbestos trafficked from Italy to Albania (see <https://en.albanianews.it/news/albania/toxic-waste-traffic>).

Trade in illegal or counterfeit pesticides

Illegal trade in pesticides is interesting to mention in the WasteForce project since there are similarities with waste trafficking. As shown in Figure 3 the pesticide fipronil already showed in criminal cases five years before there was a large incident with contaminated chicken eggs for human consumption in 2017 (European Commission, December 2017). Before 2017 fipronil had already been illegally traded and used in plant protection products with brand names like *Violin* and *Mundial* and under the false label of “Sodium Ferric EDDHA”. The dashboard free selection of combinations (Figure 5) shows some other pesticides, indicating that pesticides in general do occur in criminal investigations more regular. The pesticides mentioned in Figure 5 were not related to illegal trade. Active substances related to illegal pesticide trade are presented in table 1. All of the substances mentioned in table 1 are used as insecticides and intended for use in plant protection.

Active substance	Working mechanism
Fipronil	Neurotransmitter blocker, broad-spectrum insecticide that disrupts the insect central nervous system
Propargite	Insecticide (acaricide); non-systemic with contact action, inhibits oxidative phosphorylation
Bifenazate	Insecticide (acaricide). The product contained elevated concentrations bifenazate. Neuronal inhibitor (See photo 6 for labels)
Beta-endotoxin thuringiensis	Blocker of RNA biosynthesis; used as insecticide
Methamidophos	Cholinesterase blocker; insecticide
Acephate	Cholinesterase blocker; insecticide

Table 1 Active substances of pesticides encountered in illegal trade

Trade in illegal pesticides is a special Europol focus point. Under the name of Operation Silver Axe Europol began to target the illegal trade of pesticides in 2012. Since its launch, 1222 tonnes of illegal and fake counterfeit products have been seized (see <https://www.europol.europa.eu/newsroom/news/operation-silver-axe-strikes-for-fourth-time-seizing-over-550-tonnes-of-illegal-pesticides>).



Photo 6 Label of Omite, sold via the internet as an insecticide containing elevated levels of the active substance propargite (Photo: NFI).

5. Experiences and lessons learned

Forensic research performed in criminal cases dealing with transnational waste trafficking generates large amounts of data from different types of wastes, contaminants, production processes and recovery operations. Waste types and ways to conceal infringements are variable driving the need to develop different methods to detect waste crime and tools to handle the information collected.

The Proof of Concept tool for *Environmental Forensic Data Analysis* facilitates extraction of historic information with respect to industry sector, production process, wastes generated (type of wastes and chemical compositions), recovery operations and carriers in relation to illegal activities. Examples of data analysis on different aspects of illegal waste trafficking demonstrate that a focus on environmental forensics creates a broader perspective on waste crime over administrative and visual inspections alone.

It is important to realise that the search tools were chosen based on experience of the researchers. They are however not fixed and merely serve to illustrate the possibilities of software for data visualisation. Restrictions of the prototype for environmental data analysis are mainly related to the limitations of the *Environmental Forensics Database*.

In general, a biased database is an important pitfall in any data analysis. Smart linkage to other information sources might overcome this and improve the prototype in the future.

List of abbreviations and definitions

API	An application programming interface (API) is a computing interface which defines interactions between multiple software intermediaries. It defines the kinds of calls or requests that can be made, how to make them, the data formats that should be used, the conventions to follow, etc. It can also provide extension mechanisms so that users can extend existing functionality in various ways and to varying degrees
BlockWaste	BlockWaste, <i>blocking the loopholes for illicit waste trafficking</i> , is a research project co-funded by the Internal Security Fund of the European Union that run from 1.1.2016 to 31.12.2017
CAS	Chemical Abstract Number. A unique numerical identifier assigned by the Chemical Abstracts Service (CAS) to every chemical substance described in the open scientific literature
Entity extraction	Entity extraction, also known as entity name extraction or named entity recognition, is an information extraction technique that refers to the process of identifying and classifying key elements from text into pre-defined categories
ELV	End of life Vehicles
Frog	Frog is an integration of memory-based natural language processing (NLP) modules developed for Dutch. All NLP modules are based on Timbl, the Tilburg memory-based learning software package. Most modules were created in the 1990s at the ILK Research Group (Tilburg University, the Netherlands) and the CLiPS Research Centre (University of Antwerp, Belgium). Over the years they have been integrated into a single text processing tool, which is currently maintained and developed by the Language Machines Research Group and the Centre for Language and Speech Technology at Radboud University Nijmegen. A dependency parser, a base phrase chunker, and a named-entity recognizer module were added more recently. Where possible, Frog makes use of multi-processor support to run subtasks in parallel
IMPEL	European Network for the implementation and Enforcement of Environmental Law
LoW	European List of Waste (LoW). The LoW provides further provisions for the assessment of hazardous properties and the classification of waste. It provides the list of wastes, categorised into chapters, sub-chapters and entries. The entries in the LoW can be categorised into 'absolute hazardous entries', 'absolute non-hazardous entries' and 'mirror entries'.

	Commission Decision 2000/532/EC establishes the European List of Waste (LoW).
Parsing	Parsing is the process of analysing a string of symbols, either in natural language, computer languages or data structures, conforming to the rules of a formal grammar. The term parsing comes from Latin pars (orationis), meaning part (of speech)
RDF	Refuse-derived fuel (RDF) is a fuel produced from various types of waste such as municipal solid waste (MSW), industrial waste or commercial waste. Selected waste and by-products with recoverable calorific value can be used as fuels in a cement kiln, replacing a portion of conventional fossil fuels, if they meet strict specifications
Streamlit	Streamlit is an open-source app framework for Machine Learning and Data Science teams
SWEAP	The Shipment of Waste Enforcement Actions Project (SWEAP) project is co-funded by the European Commission LIFE fund (LIFE17 GIE/BE/000480) and will run between September 2018 to June 2023. The SWEAP project is a follow-up of the IMPEL Enforcement Actions project series. The overall purpose of the project is to support the circular economy principle and to disrupt illegal waste trade and management at an EU level
UCO	Used Cooking Oil (UCO), used vegetable oil (UVO), recycled vegetable oil, or waste vegetable oil (WVO) is recovered from businesses and industry that use the oil for cooking. It is used to feed livestock, and to manufacture soap, make-up, clothes, rubber, and as feedstock for biodiesel production
Vue Javascript	Vue Javascript is an open-source model–view–viewmodel JavaScript framework for building user interfaces and single-page applications
WEEE	Waste Electrical and Electronic Equipment
WSR	<i>Regulation (EC) No 1013/2006 on shipments of waste ('Waste Shipment Regulation' or 'WSR') implements into EU law the provisions of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (Basel Convention, 1989) and OECD Decision C(2001)107/Final</i>

References

- 2009/28/EC. (23 April 2009). *Directive on the promotion of the use of energy from renewable sources*. Official Journal of the European Union: EC.
- Basel Convention. (1989). *On the control of transboundary movements of hazardous wastes and their disposal Protocol on liability and compensation for damage resulting from transboundary movements of hazardous wastes and their disposal*. Geneva Swiss: UNEP Basel Convention.
- Buck de, A. (2011). *Blending and bunkering; Admixture of hazardous materials to bunker fuels for maritime shipping-risks and strategies*. Delft, the Netherlands: CE Delft.
- Court of Rotterdam. (2018). *Ruling (in Dutch). CEO of a shipping company is convicted for violation of the WSR*. Rotterdam, the Netherlands: <https://uitspraken.rechtspraak.nl/inziendocument?id=ECLI:NL:RBROT:2018:2108>.
- Dutch Emissions Authority. (24 August 2016). *Quick scan legislation double counting biofuels, vulnerabilities in the system? (in Dutch)*. <https://www.emissieautoriteit.nl/>: Nederlandse Emissieautoriteit (Nea).
- EC No 1013/2006. (14 June 2006). *On shipments of waste*. Official Journal of the European Union: European Parliament and the Council.
- EEB. (2020). *Crime and punishment*. Brussels, Belgium: European Environmental Bureau.
- European Commission. (December 2017). *Fipronil in Eggs*. JRC110632: Joint Research Centre.
- Grinsven van, A., Kampman, B., & Scholten, T. (June 2015). *Biofuels on the Dutch market. Update: data for 2013*. Delft, the Netherlands: CE Delft.
- Gussow, K. (2020). *Finding food fraude, explaining the detection of food fraude in the Netherlands*. Vrije Universiteit Amsterdam: Thesis.
- Human Environmental and Transport Inspectorate (in Dutch). (may 2019). *Signal report, fraude with certificated sustainable biodiesel*. The Hague, the Netherlands: Ministry of housing and environment.
- Interpol. (December 2017). *Operation 30 days of Action Final report*. Lyon France: 2017/1393/OEC/ILM/ENS/FPI.
- Meneghini, C., Favarin, S., Andreatta, D., & Savona, E. (2017). *An exploratory estimate of the extent of illicit waste trafficking in the EU*. BlockWaste blocking the loopholes for illicit waste trafficking: BlockWaste Home/2014/ISFP/AG/EFCE/7199.

Netherlands Food and Consumer Product Safety Authority. (2018). *Asbestos in cosmetic products. Study of asbestos in talc-containing cosmetic products*. Utrecht, the Netherlands: www.nvwa.nl.

Neve, R. (2013). *Globalised waste criminality illegal activities in waste transports to Africa and China (in Dutch)*. Zoetermeer Netherlands : Dutch Police.

Olley, K., Ross, N., & O'Shea, P. (Project Report 2014-2015). *Enforcement of the European Waste Shipment Regulation*. www.impel.eu: IMPEL-TFS Enforcement Actions.

Saveyn, H., & Eder, P. (2014). *End-of-waste criteria or biodegradable waste subjected to biological treatment (compost & digestate): technical proposals*. Luxembourg: European Commission Joint Research Centre.

Suivantola, L., & Kankaanranta, T. (2017). *Emerging threats in the waste trafficking sector Executive summary*. BlockWaste Blocking the loopholes for illicit waste trafficking: BlockWasteHOME/2014/ISFP/AG/EFCE/7199.

SWEAP Project. (2020, March). *Inspection results 2018-2020*. Retrieved May 25, 2020, from www.impel.eu: <https://www.impel.eu/wp-content/uploads/2020/05/SWEAP-inspection-results-2018-2020-updated.pdf>

WasteForce. (December -February 2020). *WasteForce Crime Alert #5*. <https://www.wasteforceproject.eu/resources/publications/:ISFP/2017/AG/ENV/821345>.

WasteForce. (January 2018- January 2019). *WasteForce Crime Alert #1*. <https://www.wasteforceproject.eu/resources/publications/:ISFP/2017/AG/ENV/821345>.

WasteForce. (June 2019-August 2018). *WasteForce Crime alert #3*. <https://www.wasteforceproject.eu/resources/publications/:ISFP/2017/AG/ENV/821345>.

WasteForce. (March-may 2019). *WasteForce crime alert #2*. <https://www.wasteforceproject.eu/resources/publications/:ISFP/2017/AG/ENV/821345>.

WasteForce. (September-November 2019). *WasteForce Crime Alert #4*. <https://www.wasteforceproject.eu/resources/publications/:ISFP/2017/AG/ENV/821345>.