

Abstract

The paper presents the results of a questionnaire survey carried out by The Forensic laboratory of the National Bureau of Investigation (NBI-FL), aiming to get an overview of the current status of environmental forensic science (EFS) and environmental crimes investigation in the European Network of Forensic Science Institutes (ENFSI).

A questionnaire was sent out to 71 ENFSI member institutes and the response rate was 44 %. The results of the survey indicate that the issue of environmental crime is taken seriously in most participating countries, but a need for improvement in the approach to the issue was identified. Countries define environmental crime differently and have different law structures regarding what kind of actions are considered environmental crimes. The most frequently mentioned actions were waste dumping, pollution, inappropriate handling of chemicals and hazardous waste, oil spills, illicit excavation and wildlife crime and trading.

The different roles of the authorities involved in the investigative process seem to be somewhat unclear in several countries. Most institutes participated on some level in the forensic processes related to environmental crime cases. The most common tasks performed in forensic institutes were the analysis of environmental samples and interpretation of the results. Only three institutes had case coordination services related to EFS. Participation in sample collection was rare but a clear developmental need was identified. A majority of the respondents acknowledged a need for increased scientific collaboration and education in the field of EFS.

Keywords:

Environmental crime, environmental forensic science, environmental legislation, ENFSI, survey

1. Introduction

1.1. Environmental crime

Public awareness of environmental issues has grown. Concerns about issues such as climate change and environmental protection have increased in many countries across the world and many European countries rank at the top of the list expressing high levels of concern (Poushter & Huang, 2019). The United Nations declared access to a clean and healthy environment a human right this year (United Nations General Assembly, 2022). We need strong environmental laws and institutions to protect and restore the environment. There is no single formal definition of environmental crimes or as the United Nations Office on Drugs and Crime (UNODC) defines it “crimes that affect the environment”, but in general they are considered to include criminal acts that cause serious harm to the environment and human health or both. Environmental crimes threaten the rule of law, governance and national security (UNODC, n.d.).

According to the United Nations Environment Program (UNEP) environmental crimes are a rising global threat (UNEP, 2018). It is estimated that environmental crimes generate between 110 and 281 billion USD in illicit profits yearly (Nellemann et al., 2018). One of the things that separates environmental crime from other types of crime is the aggravated damage locally, effects through additional costs and general negative impacts on the environment. These effects might be temporary but their persistence is not always clear (Nellemann et al., 2016). In fact most of the serious damage is mid- to long-term rather than immediate (IPEC, 2015). Oftentimes considerable environmental harm is due to accumulation of repeated violations rather than a single offense (Skinnider, 2013). Thus environmental crime is not easily visible and victimization is often delayed (IPEC, 2015; Skinnider, 2013). When the damages become apparent, the criminal profit has already been accrued and the offenders are long gone (IPEC, 2015).

Environmental crime ranks the third largest (by some estimates the fourth largest) in the criminal sector by profits and the annual cost impact rates are expected to grow by 5 - 7 %, which is over two times the rate of the global economy. Only drugs, counterfeit crimes are more lucrative (Nellemann et al., 2018). Still environmental crimes are underreported, representing less than 1 % of the total cases referring to Eurojust in 2014 - 2018. The most common types

of environmental crime reported included pollution crime, illegal trading in hazardous substances, as well as trafficking in waste and wildlife (Eurojust, 2021).

Environmental crime can be a lucrative business and this has not gone unnoticed by organized crime syndicates as a new form of criminal activity alongside more traditional activities (UNODC, 2012). Previously, environmental crimes have been treated separately from other types of crime. This distinction is no longer valid as organized crime groups are transcending these barriers and environmental crimes are interconnected with other categories of crime (Interpol, 2015). Transnational environmental crime is not a standalone phenomenon (van Uhm & Nijman, 2022), with 84 percent of countries reporting a convergence of environmental crime and other serious crime according to a survey by Interpol (UNEP, 2016). Criminal networks involved in environmental crime can also be involved in corruption or trafficking of drugs, firearms or human beings. According to Eurojust environmental crime is linked with other crimes about two out of three times (Eurojust, 2021).

According to UNEP, environmental crime investigation, enforcement and prosecution require further capacity building alongside more active reporting and awareness raising on the existing cases but also the risks posed by environmental crimes (UNEP, 2018). Enforcement of environmental crimes also requires specialized knowledge (Eurojust, 2021). It combines criminal and administrative approaches and often involves several national agencies and authorities (Interpol, 2015; Eurojust, 2021). The transnational nature of environmental crime places challenges on the coordination and complementarity of the actors. The multidisciplinary field lacks resources and specialized knowledge and practical experience (Eurojust, 2021). The best option is to investigate and prosecute perpetrators on a national level. Unity of efforts and sufficient resources are key elements in stopping environmental crime (UNEP, 2018).

1.2. Environmental forensic science

The Forensic laboratory of the National Bureau of Investigation (NBI-FL) in Finland, as well as colleagues in several other European countries, have observed a growing interest in questions associated with Environmental forensic science (EFS).

A number of handbooks, manuals (Drielak, 2019; Interpol, 2014a; Interpol, 2014b) and research papers (Stelling, 2022; Estoppey et al., 2019; Spikmans, 2019; Barazzetti Barbieri & de Souza Sarkis, 2018; Stelling 2009; Ramsey & Thompson, 2007) concerning EFS have been published. The scientific journal *Environmental Forensics* has been in publication since 2000, focusing on EFS related topics such as sampling techniques, environmental risk assessments and source tracing. Some of the techniques that are of use in EFS e.g. soil sampling and analysis, can also be utilized in forensic geology (Murray & Tedrow, 1975; Ritz et al., 2009; Riding, 2021). While these can be of value in the day-to-day investigation of environmental crimes, there remains a lack of general discussion concerning the specific issue of EFS. This might be due to the challenging and possibly unclear position of environmental crimes; partly handled as administrative offenses with administrative actions and in non-law enforcement institutions and partly by the national police forces.

In response to this need for discussion, the environmental crime coordination team at NBI-FL generated a pilot survey to get a better insight on how other European forensic institutes handle the subject of environmental forensic science. The survey's target group was all the member institutes of the European Network of Forensic Science Institutes (ENFSI). ENFSI has been recognized as the monopoly organization in the field of forensic science by the European commission (ENFSI, n.d.). ENFSI consists of 71 member institutes from 38 countries geographically spread across Europe. Eligibility criteria for membership include requirements regarding the institute's accreditation status as well as the services offered and status of the institute (ENFSI, 2018).

The survey aimed to gather baseline information about the state of EFS and investigations conducted by other ENFSI institutes. As such the questionnaire contains a wide set of questions regarding environmental crimes and forensic science. As a baseline survey the aim was to detect similarities and differences in national approaches and to lay out an overview of the current status of EFS in the responding institutes. The purpose of this paper is to provide a summary of the survey results and to discuss the questionnaire and what further steps could be taken to improve EFS in ENFSI institutes. We hope our work can generate more in-depth discussions and research on the topic.

2. Materials and methods

In order to get a wide range of comparable responses, a quantitative survey method was used in the form of a questionnaire. To maximize reachability and the number of respondents, an online survey tool (www.webropol.com) was used to carry out the questionnaire. Additionally, the respondents were given the option to answer via an Microsoft ExcelTM file in case they were unable to access the online survey form. The Microsoft ExcelTM file was a direct copy of the original survey. The questionnaire was distributed through the ENFSI secretariat to all 71 ENFSI institutions. Respondents were given seven working days to respond but the deadline was extended with an additional week. As the preliminary response time was short, no reminders were sent other than the notification for the extended deadline.

The survey consisted of 15 questions regarding national environmental law and the institute's role in environmental crime cases. Questions (Q-) 1 - 2 were questions regarding the perceived national importance of environmental crimes and the need for improvement, 3 - 5 were questions regarding the national legislation, questions 6 - 12 were questions regarding the forensic institutes' role in the environmental crime investigations and 13 - 15 were regarding training and development areas in the institute. The questions were rating scale questions (1 being the smallest or the least important, 10 being the largest or the most important), close-ended multiple-choice questions and open-ended questions. The questions were formulated to cover both personal opinions on the matters and factual questions about the situation in ENFSI institutes and corresponding countries. All respondents were asked to answer all questions but this was not mandatory. All survey questions and raw data of responses, excluding identifying information, can be provided on request to the corresponding author.

The statistical analysis of the numerical answers and demonstrating diagrams of the results were conducted and produced with Microsoft ExcelTM. From the open-ended questions, common themes and shared views were identified as the aim of the study was to evaluate the current status of the ENFSI members as a whole.

3. Results and discussion

In response to the survey, 31 answers were received from 21 different countries (a response rate of 44%). The survey results are presented here as subchapters that follow the structure of the questionnaire; each subchapter represents a question theme. An overview of the results from the rating scale and the close-ended multiple-choice questions are presented in Fig. 1 - 9. Figure 10 presents a correlation matrix on the rating scale questions. The results from the open-ended questions are summarized and discussed in the subchapters 3.1.2., 3.1.3. and 3.1.4., respectively. The presentation of the results follows the structure of the questionnaire to ensure readability. Some questions in the subchapter 3.1.3. are not presented in numerical order to allow for a more logical presentation and discussion.

3.1. Survey results and discussion

3.1.1. Perceived importance and need for improvement

Q1. In general, how do you see the current attitude towards environmental crimes in your country?

Q2. Is there a need to improve the national approach regarding environmental crimes?

A majority of the respondents were of the opinion that the issue of environmental crimes is, at least to some extent, taken seriously in their country, as the median answer was 8. No one considers the issue completely unimportant, as all answers were 3 or higher. At the same time a need for improvement in the approach to the issue was identified, with a median answer of 8 and no answers below 4.

Environmental issues have gotten much attention in the past years and this likely also affects attitudes towards environmental crimes. The respondent's acknowledged need for improvement on how to approach the issue follows the general and timely public opinion of the need to improve environmental protection. It also echoes the views of institutions like UNEP, UNODC and Eurojust regarding the handling of environmental crimes on national and international level.

As shown in (Fig. 1) the distribution of responses on the first two questions are similar. It seems that even though the issue is considered important, not enough measures have been taken until

now, and this shows a clear need for improvement. This also follows the general trend in actions to improve environmental protection: the attitudes might affect but do not always correspond with the actions (Bouman et al., 2021; Poussa, 2017).

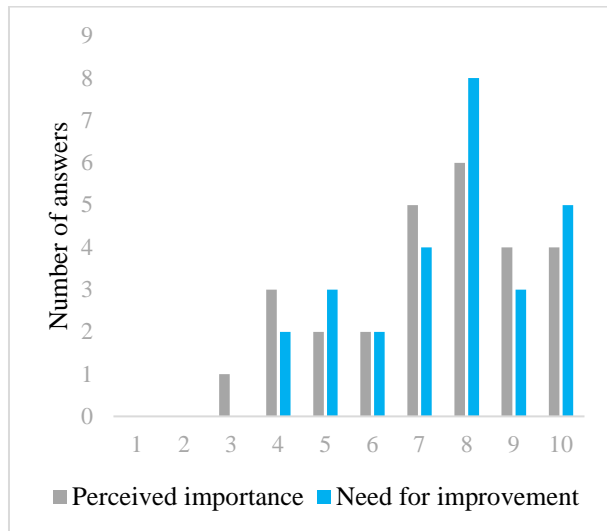


Fig. 1. Perceived importance and need for improvement regarding national approach to environmental crimes according to respondents.

3.1.2. National legislations

Q3. What kind of criminal offenses are considered environmental crimes?

The answers to the questions regarding actions that are considered environmental crimes were of differing lengths, ranging between one sentence and over 200 words. When all answers are compounded, a long list of illegal activities can be listed. The most frequently mentioned were: waste dumping, pollution, inappropriate handling of chemicals and hazardous waste, oil spills, illicit excavation and wildlife crime and trading.

The following list contains examples of illegal activities included in the replies. Causing risk of fire in nature; illegal cutting of trees and shrubs; killing birds of prey; noise; animal mistreatment; damaging of landscape; crime against protected natural space and illegal hunting and fishing; failure to take measures to eliminate the effects of environmental pollution; concealment or distortion of information about the ecological condition or morbidity of the population; violation of water protection rules; destruction or damage to flora; illegal felling or illegal transportation, storage; sale of timber; design or operation of buildings without

environmental protection systems; endangering the ozone layer; endangering the environment with radioactive substance; lack of specific documentation; transmission of infectious diseases in flora and fauna.

Some countries seem to have a very strictly defined criminal code regarding what is considered a criminal act, while the definition is more open to interpretation in other countries. The first example is more precise: “Causing risk of fire in nature, activities dangerous to flora, damaging or destruction of trees and shrubs, damaging or destruction of trees or shrubs through negligence...damaging wild fauna...operation of products prohibited in order to protect ozone layer” and so on. An example of a definition that leaves more room for interpretation is: “Failure to take measures to eliminate the effects of environmental pollution”. The latter example also highlights the fact that not all criminalized actions have to be directly affecting the environment in a negative way.

Broadly speaking, the description of the environmental crime phenomenon is approached differently in different countries. Some have no legislation on a national level in the matter, but it is rather defined regionally, as an example in Belgium (van Thuyne & Goossens, 2021; Deltour et al., 2019). How and where these actions are described differs. Actions that negatively impact the environment can in some cases be considered and handled only as administrative offenses instead. It is safe to assume that countries are more alike when it comes to defining some other types of criminal offenses, e.g. in the case of a homicide. This might affect the approach to the matter on a national level, but further study of the effects this distinction has are beyond the scope of this study.

Q4. Where and how are the criteria of environmental crime described?

Criteria of environmental crimes were described either in the national criminal law/penal code or in a single or in multiple laws regarding environment and environmental protection or a mix of all of the above. Countries may have a long list of specific environmental laws and acts pertaining to specific sub-categories (e.g. air, water, waste, forestry) or a single piece of legislation which usually carries the title of “environmental protection law” or similar. Some countries have a specific list of criminalized actions and the actions that are investigated as environmental crimes are directly contrasted to these listed actions. Anything not on the list cannot be considered an environmental crime. Other countries' legislation may only have a very

vague and short description of what is or isn't an environmental crime. In some countries, environmental regulation originates directly from the European Union (EU) regulations.

Answers to this question were not offered as quantitative data as wording and contents of the laws might differ and an in-depth analysis of different countries' laws are outside the scope of this study. Environmental crime legislation varies from country to country, and as shown, in some cases even within one country. This might create problems in tackling transnational environmental crime as international cooperation has to accommodate different sets of rules.

Q5. How precise is the term environmental crime?

The term “environmental crime” seems to be precise or quite well defined to the majority of the respondents, as most answers are above 5 (Fig. 2). However, only one respondent rated the term with a 10, which gives an impression that the term raises some uncertainty.

It is assumed that respondents mainly considered the question in regards to their own national legislation and as such this question might not offer much when considering international or transnational cooperation. Also, in countries where legislation clearly defines the actions that are regarded as criminal, it is more likely that the term environmental crime is considered to be precise.

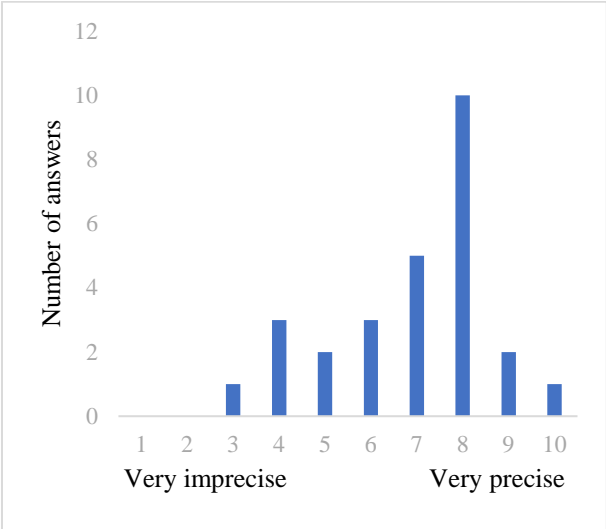


Fig. 2. Precision of the term environmental crime according to respondents.

3.1.3. The forensic institute's roles in the investigation of environmental crimes

Q6. In your opinion, how involved is the forensic laboratory in the forensic process regarding environmental crimes?

Q7. What is the importance of environmental forensics as a topic in the hierarchy of forensic disciplines in your laboratory?

Q8. Where do the environmental forensics rank in comparison to other forensic disciplines in your laboratory in terms of number of cases?

The institute's level of involvement in the forensic process varied. Many institutes participated to some extent in the forensic processes related to environmental crime cases, but the majority seem to have a limited role, as the majority of answers ($n = 21$, 68 %) were 4 or below (Fig. 3). However, the answers ranged from 1 to 10. Similarly, the topic of environmental crimes ranked low in the hierarchy of forensic disciplines in their institute (median = 3) (Fig. 4). In terms of number of cases, EFS clearly ranks low in comparison to other forensic disciplines in institutes: 87 % of respondents rated them 5 or lower (median = 2) (Fig. 5).

That the topic of environmental crimes ranks low in the hierarchy among other forensic disciplines, could be interpreted as a consequence of the low number of cases proceeded and the institutes' low involvement in the forensic process of environmental crime investigation. Why this is the case is again beyond the scope of this survey, but the following questions point out that the institutes' role in the environmental crime investigation process is somewhat unclear.

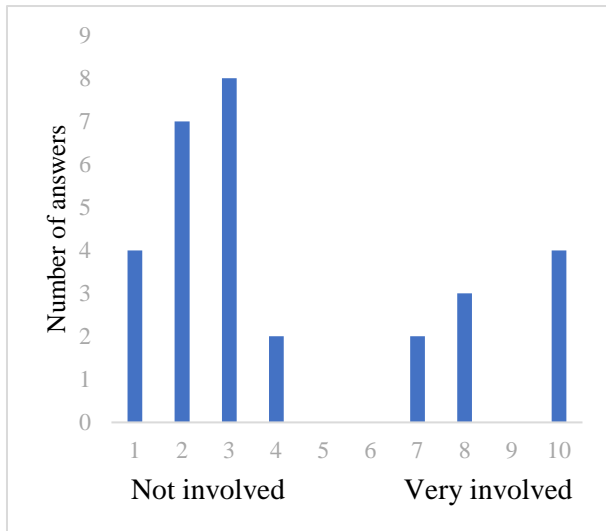


Fig. 3. Involvement of respondent's institutes in environmental crime cases.

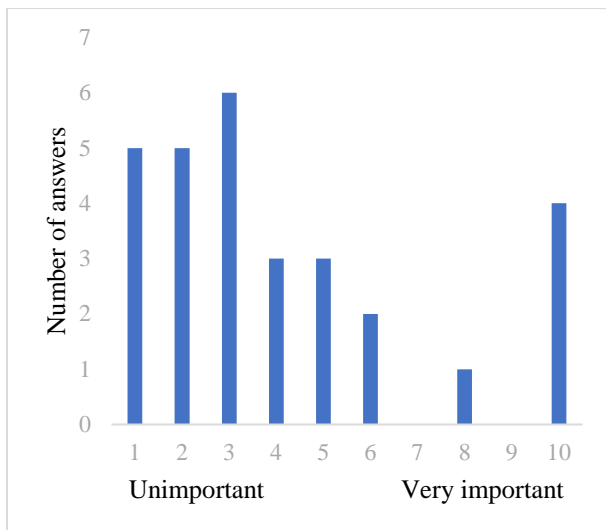


Fig. 4. Environmental crimes in the hierarchy of forensic disciplines in the respondent's institutes.

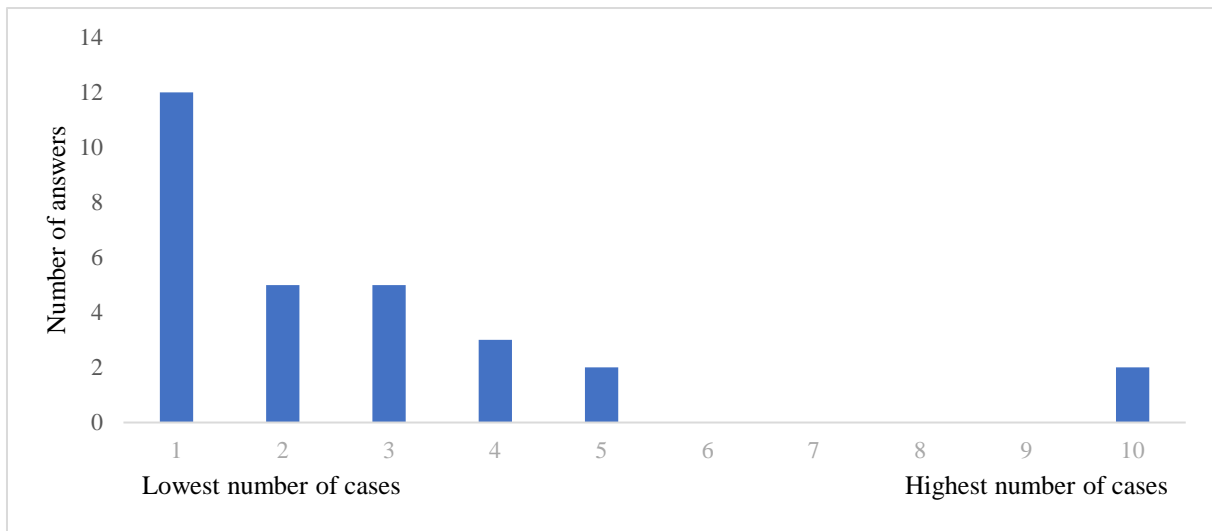


Fig. 5. Environmental crimes in the hierarchy of forensic disciplines in terms of cases in the respondent's institutes.

Q9. Does your laboratory have designated persons who are specialized in matters relating to environmental forensics?

Q11. What role(s) does the forensic laboratory play in the environmental forensic process?

Over a third of the respondents ($n = 12$, 39 %) had at least one designated person specialized in the matter in their institute but only seven (23 %) reported having more than two (Fig. 6). Clearly the most common tasks regarding environmental crimes performed in forensic institutes is the analysis of environmental samples ($n = 18$, 58 %) and interpretation of the results ($n = 15$, 48 %). Institutes rarely collect samples themselves as only 16 % ($n = 5$) of the respondents do so. Only three institutions (10 %) had case coordination services related to EFS and seven (23 %) had no role whatsoever in the forensic process related to the investigation of environmental crimes (Fig. 7).

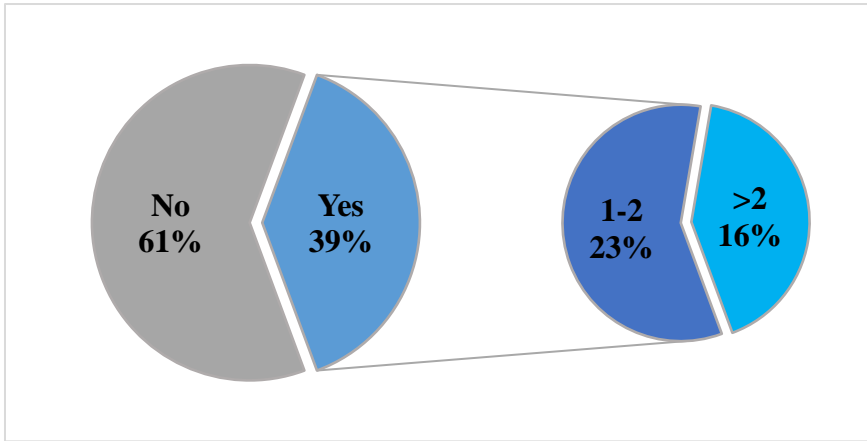


Fig. 6. Personnel designated to EFS in respondents' institutes.

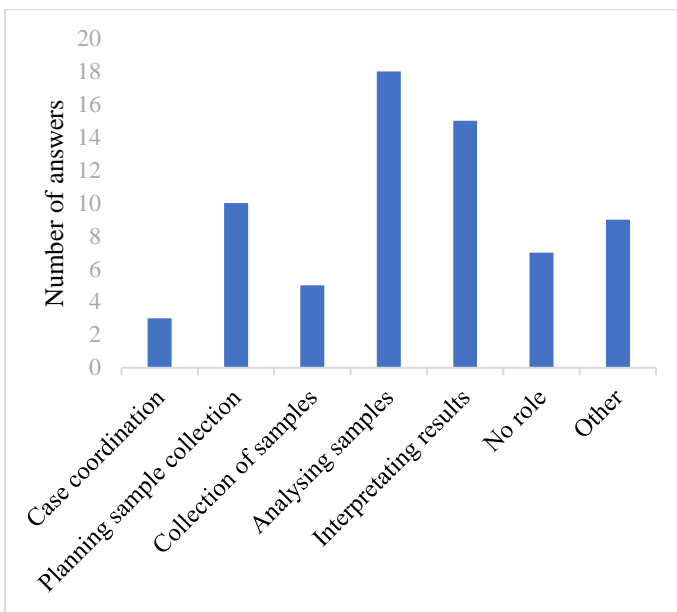


Fig. 7. Roles in the environmental forensic process of the respondents' institutes.

Q10. How well does the role of the forensic laboratory fit with the responsibilities and roles of the other officials involved in the process (e.g. investigative police, prosecution, environmental authorities)?

Q12. In your opinion, what role could or should the forensic laboratory play in the environmental forensic process compared with the current role?

The results varied widely, ranging between 1 and 10 (median = 5) (Fig. 8). The desired role of forensic institutes in environmental crime investigation varies widely as well, but there is a trend in the answers showing that the issue is considered rather new and timely. Many acknowledged a need to invest in it. Some acknowledged it as a way to help and promote environmental protection.

In some countries the role is small and these respondents see little need to improve their capabilities as they consider that the topic does not fall under their responsibility. This might be due to the fact that the investigation of environmental crimes is handled by other authorities. Others see the need for improvement, but see challenges in developing something from scratch, as it would be time-consuming and costly. The current situation of the institute and country in question will likely influence the future prospects of development in this matter.

If the answers to questions 10 and 12 are considered together, one gets the impression that the roles of the forensic institutes in environmental crime investigations are varied and somewhat uncertain and undefined.

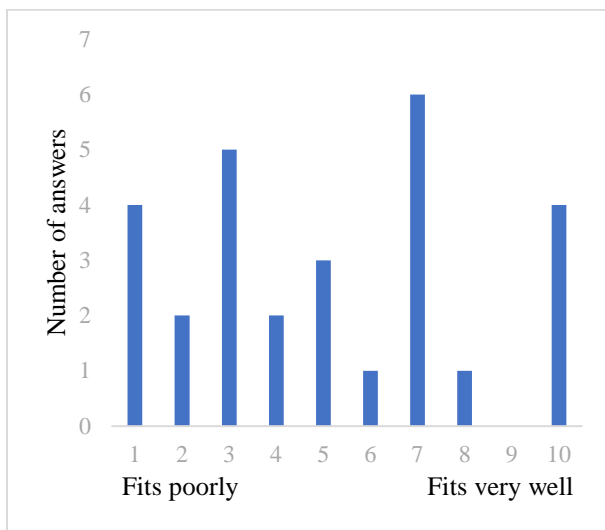


Fig. 8. Respondents' institutes fit regarding roles and responsibilities with other officials.

3.1.4. Training and development areas

Q13. What kind of expertise does your laboratory currently have in the area of environmental forensics?

Q14. What kind of training and development needs does your laboratory have in the area of environmental forensics?

Q15. Would your laboratory be interested in joining an ENFSI project group or an informal network covering environmental forensics?

The level and range of expertise varied widely from no expertise at all to e.g. chemical expertise, different kinds of water analysis (micropollutants as an example), heavy metal analyses, collection of samples and X-ray fluorescence (XRF) testing of waste. Respondents were also asked to describe what kind of training and development needs their institutes have. The answers were distributed quite evenly but the most popular answers mirrored the existing roles of the institutes with interpretation of results (n = 14, 45 %), sample analysis (n = 13, 42 %) and sample collection (n = 11, 35 %), communication of results (n = 10, 32 %), planning of sample collection (n = 9, 29 %) and environmental legislation (n = 9, 29 %). Only 13 % (n = 4) needed training in case coordination (Fig. 9). Answers resemble the current roles held by institutes with the exception of sample collection. Only five respondents reported participating in the collection of samples currently but 11 respondents identify this as a development need. The majority of the respondents (65 %) saw a need for collaboration and education in the field of EFS.

Not all institutes were involved in environmental crime investigations and as such they don't possess extensive expertise on the topic. The results are similar to the first questions as many institutes identify a need to improve and develop the field. Respondents showed interest also in topics that their institutes do not currently take part in.

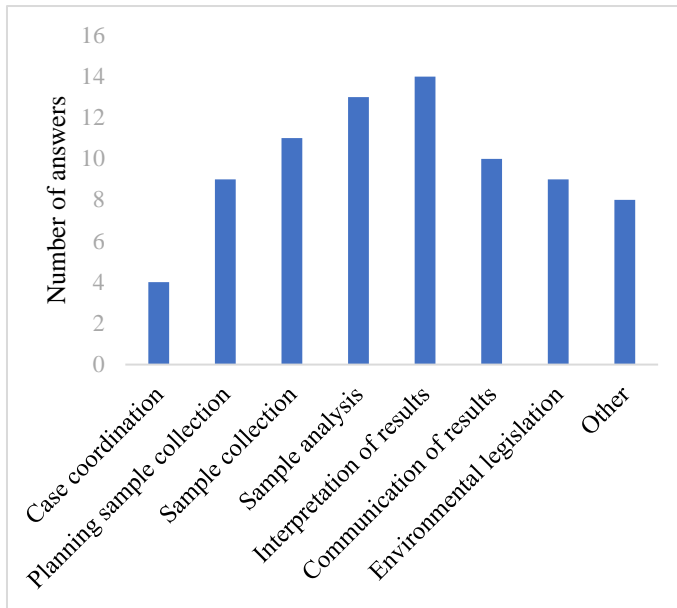


Fig. 9. Training and development needs in EFS in respondents' institutes.

3.1.5. Correlation coefficient

A correlation matrix was used to measure the relationships of the variables (Fig. 10). There are several different approaches to interpret the results of the correlation coefficient but in this paper a streamlined version of a commonly used approach was utilized (weak correlation 0.00-0.39; moderate correlation 0.40-0.69; strong correlation 0.70-1.00) (Schober et al., 2018).

The strongest correlation was found between questions 6, 7 and 8 (Fig. 10), which are all questions regarding EFS in respondents' own institutions. Strong or borderline strong correlations between the level of involvement, perceived importance of the discipline and the number of cases were observed. The strongest correlation was observed between the number of cases and the importance of the discipline (0.785). Based on the survey, it is not possible to claim causal relations between the variables. Thus, it cannot be evaluated if for example a rise in the number of cases would impact the perceived importance and the level of involvement of institutes or vice versa.

Contrary to authors' expectations, no correlation was observed between Q1 and Q2 (0.087), even though the distribution of the answers were similar (Fig. 1). Weak to moderate correlation was also detected between questions Q1 and Q6 (0.342), Q1 and Q7 (0.519) and Q1 and Q8 (0.437). Similar weak to moderate correlations were detected between Q10 and Q6 (0.386) and Q10 and Q7 (0.408).

	<i>Q1</i>	<i>Q2</i>	<i>Q5</i>	<i>Q6</i>	<i>Q7</i>	<i>Q8</i>	<i>Q10</i>
Q1	1.000						
Q2	0.087	1.000					
Q5	0.058	0.047	1.000				
Q6	0.342	0.189	-0.067	1.000			
Q7	0.519	0.406	-0.004	0.706	1.000		
Q8	0.437	0.262	0.052	0.686	0.785	1.000	
Q10	0.249	0.067	0.207	0.386	0.408	0.277	1.000

Fig. 10. The results of the survey in a Pearson correlation matrix. The correlation coefficients are presented with the following color-coding: light blue 0.00 to 0.39; blue 0.40 to 0.69; dark blue 0.70 to 1.00; light red 0.00 to -0.39.

3.2. Summarizing discussion and future prospects

3.2.1. An evaluation of the survey

The response rate to the survey was considered good, considering the short response time of two weeks. Had the response rate been higher, the coverage would have been better, and it would have given a more pervasive insight on the state of investigation of environmental crimes in ENFSI institutes. It must also be noted that taking part in the survey may signal an initial interest in the subject. This might lead to skewed results as institutes and personnel who view this topic as important might be more motivated to fill the questionnaire compared to institutes who aren't involved in the field.

All respondents did not answer all of the questions. At most a question was left unanswered four times, and most questions received 29 or more answers. Some questions were personal opinion questions, and it must be noted that a personal opinion can say only so much about the general opinion of the institute. All answers from the same country were from different institutes within the country.

The answers to the open-ended questions corresponded to what was asked, which is interpreted as the questions were understood. In most questions the answers were quite spread out. When interpreting answers from rating scale questions, one must consider that respondents might evaluate the scale in different ways. One may consider that 6 ranks high, while someone else

sees 6 as low. It would be interesting to see if the results were different if the rating scale questions had a 1-5 scale instead, as it likely would have resulted in less spread-out responses.

This was a pilot survey on the matter and considering that the topic in many countries is still in the developing phase, the survey was considered successful for its purpose.

3.2.2. Summarizing discussion

There are differences in the ways that countries define environmental crimes. A few institutes are very involved in the process, and some have multiple specialized personnel. Whether the institutes had a big role or no role at all, some are satisfied with the current situation or at least view it as functional. Environmental crime investigation raises interest among the responding ENFSI institutes and most of the institutes that responded to the survey consider it a timely topic. Most respondents acknowledged a need for further education and development and they remain open for future international collaboration.

The current role that the institutes have in the process of environmental crime investigation is in many institutes small, somewhat uncertain and needs improvement. Based on the results, it is not possible to ascertain whether the potential challenges outlined in this survey (e.g. unfit roles of the institutes, limited case numbers or a small number of personnel) are the reasons for or the consequences of the current status of the ENFSI institutes.

As indicated by the survey results and the literature cited, environmental crime consists of a diverse set of actions that are often but not always or exclusively considered criminal. For the most part, the following categorization can be made regarding the most common types of environmental crimes: pollution, waste dumping, inappropriate handling of chemicals and hazardous waste, wildlife crime and trafficking of waste and wildlife. How and where these actions are described differs between countries.

Many authorities can be involved in the field of environmental crimes at the same time and according to the results it is not rare that the roles and assignments between these actors are unclear or not functioning in the most efficient way. This can further challenge environmental crime investigation as it is a multidisciplinary field often requiring specialized expert knowledge and personnel with experience can be rare. Transnational cooperation proposes again a different set of difficulties when many different actors will have to accommodate several

sets of regulations and practices. This has to be taken into account also in planning and designing of the further joint educational events.

As a next step it would be interesting to find out what kind of actions different institutes and countries regard as possible ways to improve the matter in their institutes. For this, an ad hoc environmental forensic group for interested ENFSI institutes has been planned and implemented. The aim is to share ideas and to organize joint educational events on the topic of forensic environmental crime investigation.

Nevertheless, the topic is current and critically important. We are hopeful that future international interdisciplinary collaboration can generate more in-depth discussion as well as develop the field of EFS in general.

4. Conclusions

Definitions of environmental crime vary on a country-to-country basis. The laws regarding environmental crime are also structured differently, however, waste dumping, pollution, inappropriate handling of chemicals and hazardous waste and oil spills are among the most common actions considered as environmental crimes.

EFS is a small discipline in ENFSI institutes in regards to case numbers and designated personnel. The current role of institutes in the process of environmental crime investigation is in many institutes small, somewhat uncertain and needs improvement. However, a few institutes are very involved in the process and some have multiple specialized personnel. A strong correlation between the level of involvement and the perceived importance of the discipline was observed.

A general interest for improving expertise in EFS in ENFSI institutes was clearly observed in the survey. The majority considered the topic important and are open to future international collaboration.

References:

Barazzetti Barbieri, C. & de Souza Sarkis, J. E. (2018) Estimating the uncertainty from sampling in pollution crime investigation: The importance of metrology in the forensic interpretation of environmental data. *Forensic Science International* 288 14-22.

<https://doi.org/10.1016/j.forsciint.2018.04.005>

Bouman, T., van der Werff, E., Perlaviciute, G., & Steg, L. (2021) Environmental values and identities at the personal and group level. *Current Opinion in Behavioral Sciences* 42, 47–53.

<https://doi.org/10.1016/j.cobeha.2021.02.022>

Deltour, B., Provost, L., Vendegaart, V. & Thiéry, Z. (2019) Environmental law in Belgium.

Retrieved from: <https://www.lexology.com/library/detail.aspx?g=ba407fd4-5970-4fd6-ba9c-954acda1882f>

Drielak, S. C. (2019) Environmental crime: evidence gathering and investigative techniques (Second edition.). Charles C Thomas, Publisher, Ltd.

ENFSI, European Network of Forensic Science Institutes. (2018) ENFSI Constitution.

ENFSI, European Network of Forensic Science Institutes. (n.d) Retrieved from:

<https://enfsi.eu/>

Estoppey, N., Bozic, S., Pfeiffer, F., Benejam, T. & Borel, C. (2019) Monitoring of micropollutants in rivers of the Lake Geneva basin using passive sampling. Technical Report.

Eurojust (2021) Report on Eurojust's Casework on Environmental Crime.

Interpol (2014a) Pollution Crime Forensic Investigation Manual, Volume I of II.

Interpol (2014b) Pollution Crime Forensic Investigation Manual, Volume II of II.

Interpol (2015) Environmental Crime and its Convergence with other Serious Crime.

IPEC, Intelligence Project Environmental Crime (2015) Report on Environmental Crime in Europe.

Murray, R. C. & Tedrow, J. C. F. (1975) Forensic geology; earth sciences and criminal investigation. New Brunswick, N.J., Rutgers University Press.

Nelleman, C., Henriksen, R., Kreilhuber, A., Stewart, D., Kotsovou, M., Raxter, P., Mrema, E. & Barrat, S. (2016) The Rise of Environmental Crime – A Growing Threat To Natural Resources Peace, Development And Security, Nairobi: United Nations Environment Programme and Interpol. <https://wedocs.unep.org/20.500.11822/7662>

Nellemann, C.; Henriksen, R., Pravettoni, R., Stewart, D., Kotsovou, M., Schlingemann, M.A.J, Shaw, M. and Reitano, T. (Eds). (2018) World atlas of illicit flows. A RHIPTO-INTERPOL-GI Assessment. RHIPTO -Norwegian Center for Global Analyses, INTERPOL and the Global Initiative Against Transnational Organized crime.

Poushter, J. & Huang, C. (2019) Climate Change Still Seen as the Top Global Threat, but Cyberattacks a Rising Concern. Pew Research Center.

- Poussa, L. (2017) Environmental awareness of Finns slow in moving from words to action. Retrieved from: <https://www.sitra.fi/en/news/environmental-awareness-finns-slow-moving-words-action/>
- Ramsey, M. H. & Thompson, M. (2007) Uncertainty from sampling, in the context of fitness for purpose. *Accreditation and Quality Assurance volume 12* 503–513. <https://doi.org/10.1007/s00769-007-0279-0>
- Riding, R. D. (2021) The forensic utility of reworked geological materials in soil. *Forensic Science International* 327. <https://doi.org/10.1016/j.forsciint.2021.110942>
- Ritz, K., Dawson, L. & Miller, D. (2009) Criminal and environmental soil forensic science. Dordrecht. ISBN 978-1-4020-9204-6.
- Schober, P., Boer, C. & Schwarte, L. (2018). Correlation Coefficients: Appropriate Use and Interpretation. *Anesthesia & Analgesia* 126(5) 1763-1768. <https://doi.org/10.1213/ANE.0000000000002864>
- Skinnider, E. (2013) Effect, Issues and Challenges for Victims of Crimes that have a Significant Impact on the Environment. International Centre for Criminal Law Reform and Criminal Justice Policy.
- Spikmans, V. (2019) The evolution of environmental forensic science: From laboratory to field analysis. *WIREs Forensic Science* 2019; 1 1–15 <https://doi.org/10.1002/wfs2.1334>
- Stelling, M. & Biezeman, A. (2009) Sampling strategies in environmental criminal cases. Proceedings of the 2009 INEF Annual Conference. 275–288.
- Stelling, M., Biezeman, A., Korthagen, E. & Verstappen, G. (2022) On-site detection of mercury. Technical report ISFP-AG-OC-ENV-869173.
- UNEP, United Nations Environment Programme (2016) Strategic Report: Environment, Peace and Security – A Convergence of Threats. <https://wedocs.unep.org/20.500.11822/17008>
- UNEP, United Nations Environment Programme (2018) The State of Knowledge of Crimes that have Serious Impacts on the Environment. <https://wedocs.unep.org/20.500.11822/25713>
- United Nations General Assembly (2022) The human right to a clean, healthy and sustainable environment. UN Doc A/76/L.75.
- UNODC, United Nations Office on Drugs and Crime (2012) Digest of Organized Crime Cases. A Compilation of Cases with Commentaries and Lessons Learned, New York: United Nations.
- UNODC, United Nations Office on Drugs and Crime (n.d.) UNODC Approach to Crimes that Affect the Environment. UNODC Approaches. Retrieved from: [UNODC Approach to Crimes that Affect the Environment.pdf](https://www.unodc.org/documents/organized_crime/UNODC_Approach_to_Crimes_that_Affect_the_Environment.pdf)
- van Thuyne, G. & Goossens, F. (2021) Environmental Law and Practice in Belgium: Overview. Practical Law. Retrieved from: [https://uk.practicallaw.thomsonreuters.com/2-503-5135?transitionType=Default&contextData=\(sc.Default\)&firstPage=true](https://uk.practicallaw.thomsonreuters.com/2-503-5135?transitionType=Default&contextData=(sc.Default)&firstPage=true)

van Uhm, D. P. & Nijman, R. C. (2022) The convergence of environmental crime with other serious crimes: Subtypes within the environmental crime continuum. *European Journal of Criminology*, 19(4), pp. 542-561. <https://doi.org/10.1177/1477370820904585>