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Commentary

Forensic science and environmental offences: Litter, DNA analysis and surveillance

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ABSTRACT

Items of litter such as chewing gum, cigarette butts, and dog droppings are each small but collectively have considerable negative environmental impacts. Accordingly, governments at all levels have used media campaigns to raise awareness of the environmental issues associated with litter in efforts to prevent its proliferation. In a similar vein, artists have developed thought-provoking works about waste and litter, including some about the potential to identify litter culprits through DNA analysis. In a case of life imitating art, recent advances in DNA analysis techniques make possible a range of ways in which DNA taken from litter could be used, including for purposes of social regulation. This article discusses examples of the use of litter as a source of DNA for analysis and the resulting genetic surveillance. In doing so, it raises questions about proportionality and justifications for such uses of DNA analysis techniques in regard to regulation and enforcement objectives, with particular concerns about permissions, privacy and the public interest.

Introduction

Widespread and chronic despoilation, destruction and degradation of the environment has heightened public concern about environmentally harmful activity, such as the illegal disposal of waste and the dispersal of plastics in oceans [1]. The contamination and pollution of air, land and water affects billions of people worldwide; indeed, it affects everyone, everywhere. The scale of the harm is both global and local, ranging from planetary climate effects to reductions in the aesthetics and vitality of local neighbourhood amenities such as parklands. In and amongst the calls for greater action on environmental issues are demands to reduce litter, including that contributed by animal companions such as dogs.

This article explores how forensic technologies are and/or could be deployed to counter and prevent crimes against the environment. Our specific focus is littering and the application of DNA analysis. Recent years have seen a wide range of technological and social innovations in regards environmental crime prevention, detection, investigation, and prosecution. These have included, for example, the use of microchips in wood and seafood products to track their movements from country of origin to country of destination, satellite and drone surveillance of changing land use and land clearing, chemical composition analysis of oil spills, and DNA identification of salmon and abalone for the purposes of criminal prosecution [2]. Most of the associated forensic techniques have been applied in relation to serious environmental crimes, such as wildlife trafficking (flora and fauna), illegal fishing and illegal logging, and cyber-related environmental crimes (see e.g., [3]).

The increasing use of forensic techniques and technologies to combat environmental crime is generally welcomed. However, at the same time, as we outline below, there is a tendency to escalate the uses (and thereby also the potential misuses) of such technologies across a spectrum of activities that, while harmful, are not generally considered particularly serious or criminal. Our perspective on these issues – in particular, the extension of forensic technologies to new domains of social interaction – is informed by the key principles of critical forensic studies [4]. Among other things, these principles recognise forensic science and its application in the justice sphere as a social process, with consequences for social justice and human rights. This means that how forensic science and technology is applied in practice involves many different stakeholders and power relations; it can enhance criminal and social justice outcomes, but it can also result in unequal or unjust outcomes. Part of our concern in the present paper is to consider questions of proportionality and human rights. Are we applying sophisticated forensic skills and expertise to tackle what are, in effect, problems of less importance than criminal offences? Do the technologies deployed intrinsically intrude upon privacy, and ultimately, respect for human rights? Could

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the public interest be better served using other social mechanisms such as education and community participation?

To consider these questions, the article discusses the potential for forensic DNA analysis to be used on DNA obtained from litter and the issues that such genetic surveillance raises. It first outlines the offence of littering, its environmental impacts, and approaches to addressing it, including through thought-provoking representations. These representations are significant not only as they identify environmental issues worthy of public concern, but in some cases, the artworks themselves embody elements of forensic techniques and technology relevant to our considerations of DNA analysis and litter. The article next discusses developments in DNA analysis techniques before exploring examples of how they may be used to analyse DNA obtained from litter. Matters of surveillance and privacy are raised as issues warranting further attention. A discussion of the public interest concerns arising from such applications reiterates the importance of critical forensic studies in examining the roll-out and evolution of forensic techniques from a perspective that values human rights and social justice.

Waste, litter, regulation and representation

There are extensive rules and laws that guide the definition, processing and disposal of waste [5]. Depending upon its classification (e.g., as medical, radioactive, household, or industrial), waste is regulated by different authorities. Its hazards are variable and can change over time. Waste can contribute to pollution and contamination of air, water, and land. Some waste has recycling value; other waste must be stored, incinerated, or buried. Laws are designed to allow a predetermined amount of pollution, through licensing schemes, although some activities associated with pollution and waste are prohibited in their entirety, such as the illegal dumping of toxic waste [6].

Just as there are different kinds of waste and waste regulation, offences range from the very minor (e.g., low level administrative breaches of license or violations of law) to the serious and major (e.g., transnational trafficking of hazardous waste) [6]. Littering as an offence is 'illegal' but not necessarily 'criminal'. That is, it tends to be located at the less serious end of the harm spectrum. This makes littering, as a form of waste disposal, a regulatory matter, one that rarely involves more than imposition of a fine or warning from relevant state officials. This is not to diminish the cumulative consequences of litter; if left unchecked, the scale of pollution of the landscape can be significant, especially if normalised among the local population (i.e., everyone does it because it is part of the norm of a community – for example, burying cigarette butts in the sand used to be part of the beach-going tradition in Australia, until smoking garnered sufficient public disapproval that such practices were likewise curtailed). Single acts of littering tend to bring forth penalties proportionate to the level of the offence. Dropping a piece of paper or flicking a cigarette butt to the ground is usually seen as a minor violation, worthy perhaps of a small fine but nothing more. Nonetheless, the overarching impacts of littering are, like waste issues in general, increasingly recognised as problematic in the public eye.

So, what is litter? Litter is broadly defined as rubbish or trash left lying in public places [7] although the legal definition is given wide interpretation [8]. As defined in England, the offence of littering refers to "what is done to the litter rather than what it is"; it is items left, thrown, dropped or disposed of, which cause "defacement in a public place", that is; it is not the items themselves that are problematic [9]. However, a common aspect of various definitions of litter is that it is a visible form of pollution [8] that typically consists of small personal discarded trash such as cigarette butts, chewing gum, single-use plastics in any form, paper items, glass and metal scraps. Both Australian and English jurisdictions view litter in two categories: non-biodegradable or harmful litter such as syringes, cigarette butts, chewing gum, plastics and dog droppings, and the more acceptable or less harmful types of litter, which will decompose, such as fruit peels and cores, paper, cardboard and food items [8].

Litter presents several environmental, social, and economic problems. It accumulates in the environment posing a risk of contamination of land and waterways, causing safety hazards for both humans and animals [9]. Litter contributes to the amount of plastic in the ocean, currently estimated at 93,000 imperial tons floating at the surface of the ocean, and is harmful to marine life, while unsightly street litter results in high clean-up costs; for example, England spends around £1 billion and the USA spends up to $11 billion annually in litter clean-up [10]. Cigarette butts, often made of plastic cellulose acetate, contain toxic chemicals which are leached into the soil, pollute ground water and are harmful to animals and children if swallowed [11]. They are also the leading item littered with an estimate of 766,571 metric tons of cigarette butts deposited annually into the environment [12].

Despite the impacts of litter on the environment, it is still generally viewed as a regulatory transgression; in this it is often bracketed with anti-social behaviour such as swearing or viewed as a social problem as opposed to an individual transgression [13].

Media and creative ventures, such as public art installations, are impactful vehicles for information and awareness campaigns regarding litter and its impacts on the environment [14] and provide an important counter-weight to traditional views and responses to litter. In recent years, such approaches have been associated especially with visualising the global problems associated with plastic waste [15]. For example, Indonesian environmentalists created a museum made entirely of plastics in an effort to shape people's thinking around single-use plastics [16]. Additionally, media and creative ventures have been used to highlight the harms of common litter such as cigarette butts and chewing gum. For instance, the Suffolk Litter Control Office Initiative invited local artists to participate in making artworks to help fight litter. One of the initiatives involved the collection of plastic bottle tops to create mosaic artworks, while another involved creating giant cigarette butts that can be taken to events as a talking point [17].

According to Zubiaurre [18], artists are attracted to trash "because of its threatening monumentality" (p. 64). However, not all art installations are monumental. Artist Ben Wilson (https://www.isupportstreetart.com/artist/ben-wilson/), uses discarded chewing gum found stuck on the footpaths of London as tiny canvases for his paintings. These chewing gum images speak directly to the city dweller and reflect the culture of consumption and waste [19]. Similarly, the artistic collaborative group TRES used discarded chewing gum to create site-specific installations, interventions, exhibits, and workshops in Mexico (https://tresartcollective.com/2012-Chicle-y-pega). They viewed the spat-out chewing gum as artefacts packed with stored information – of human saliva, DNA, bacteria and environmental pollution – which functions as geographical locators and indicators of human conception [18].

In a different work (https://tresartcollective.com/2011-Huella-latente), TRES used discarded cigarette butts to portray the individual character of trash. The work consists of a catalogue of 40,000 cigarette butts, conjoining a series of singular gestures into social portraits. Each cigarette butt had imprinted aspects of the personality of the person who had consumed it from lip impression, trace DNA, saliva residue, and the gesture used to put out the cigarette [20]. Although TRES analysed only the visible attributes of each cigarette butt, such as lip impression, lipstick smears and the imagined gesture used to put out the cigarette inferred from its creases and compressions, they acknowledged that had traces of DNA from the butts been analysed it may have been possible to identify some externally visible characteristics of the smoker. In their installation work, they acknowledge the idea that trash, as illustrated through chewing gum and cigarette butts, is not just garbage but "cultural artefacts laden with complex information" [18 p. 72]. These kinds of artworks prompt thinking about the relationship between litter and DNA and how items discarded as litter could become sources of DNA for analysis.

Forensic DNA analysis

DNA is unintentionally discarded by shedding bodily matter such as skin cells, sweat, and hair, and through bodily fluids, such as saliva, semen, urine, hair and blood, even in trace amounts [21]. The potential therefore exists for a range of DNA analysis techniques to be used on DNA obtained from litter. As DNA is found in cells and contains general information common amongst people as well as personal information, including identification markers (unique to an individual except in identical twins) and ancestral history [22], the potential to exploit litter as a source of DNA for analysis warrants consideration.

Since its introduction in the late 1980s, forensic DNA analysis has been used in the criminal justice process and is considered an invaluable investigative tool [23]. Four waves of social commentary on forensic DNA analysis have been described [24]. In the first wave (from 1985), the use of DNA analysis was introduced as a tool in police investigations and as evidence in the courts. Arguments and debates about the science and its legal applications were aired widely, and ultimately DNA profiling (which shows individual differences, but uses 'non-coding' regions of DNA) came to be accepted internationally. A DNA profile can be developed from such bodily matter found on a victim or at a crime scene and linked to a specific person, a possible suspect [25]. In its early days, DNA samples for comparison purposes were obtained through mass screenings or dragnets of large groups of people [26]. This made it possible to develop and compare DNA profiles to the crime scene DNA profile [22]. The refusal of a person to give a DNA sample voluntarily when collected in this way raised suspicion of guilt in the face of a right against self-incrimination [27]. In 1988, a decade before Germany introduced their DNA database, a dragnet was used to collect DNA samples from 16,400 people in the investigation of a rape and murder victim. The accused gave his blood sample voluntary, without being informed of the DNA analysis, and as the results of the DNA analysis seemed to indicate his guilt, he pleaded guilty to the crime [28]. In the investigation, doubt was cast over 16,399 individuals without reasonable suspicion of involvement in the crime for no reason other than having been in the geographical area at the time of the crime. A refusal to donate a sample would have been viewed as suspicious, thereby infringing on their right not to incriminate themselves and their right to be viewed innocent before conviction.

The second wave (from 1995 and ongoing) saw the establishment of DNA databases with acknowledged benefits, such as identification and exoneration [24]. This strengthened the primary purpose of forensic DNA analysis to identify the source of DNA found on a victim or at a crime scene and to identify people who are forensically linked to a crime scene [29]. For the DNA database, a DNA profile is created from a reference DNA sample taken from the person. The process involves using the short tandem repeats (STRs) from non-coding parts of a DNA molecule. This allows for the creation of a digital database with different categories, such as one for DNA profiles from known suspects and convicted persons along with one for crime scene profiles. It enables linking of different crime scenes as well as speedy and accurate identification or exoneration of people of interest [24]. National forensic DNA databases were installed throughout the jurisdictions of developed countries, making it an important crime investigation tool. DNA databases also allow for the sharing of DNA profiles across jurisdictions. For example, the Prüm decision saw member states of the European Union obliged to install national DNA databases to facilitate cross-jurisdictional sharing and comparisons [30]. Privacy concerns associated with this wave include the arrangements for storage and destruction of DNA samples and profiles, and concerns about cross-jurisdictional sharing due to differences in such arrangements [31].

Advancement in genetic research enabled the mapping of the human genome, which makes it possible to identify genetic characteristics found in our DNA [32]. With the mapping of the human genome, the development of the third wave (from the early 2000s and ongoing) in forensic DNA analysis started [24]. During this wave, the use of partial matches, such as familial searching were introduced into the investigation of criminal cases [33]. As a DNA profile can demonstrate genetic relationships, using familial searching, a DNA profile from a crime scene can be linked to a suspect via the DNA of a close family member who appears on a criminal database [34]. One of the key issues that arises is that because certain population groups are over-represented on criminal DNA databases, they can be under increased genetic surveillance relative to other groups. Certain risks are associated with making inferences of family relationships. These include a perception of guilt by association, the discrimination of family groups that are over-represented on the criminal database, a revival of discriminatory ideas of biological determinism, and associated views about the genetic propensity towards certain conduct [33]. The third wave also includes DNA phenotyping, which allows for the prediction of externally visible characteristics – such as eye, hair and skin colour – as well as biogeographical ancestry information. As emphasised by Schneider et al. [35], these techniques do not aim to identify a specific individual (as is the case with STR-profiling), but rather to indicate what features an unknown person may have. Thus, it is for intelligence rather than investigative purposes, as a kind of genetic witness that may be more reliable than an eyewitness [36]. Concerns associated with this approach focus on the potential to stigmatise specific ethnic and racial groups, which may already be marginalised.

Finally, the fourth wave (from 2010s and ongoing) capitalises on next generation sequencing and reflects a blurring of the boundaries between medical and forensic genetics [25]. Making use of the technological progress stemming from the Human Genome project, the primary potential replacement for STR identification has been identified as the use of the sequence variants that occur throughout the human genome known as single-nucleotide polymorphisms (SNP), with abundant SNP loci having been characterised and studied in various human populations [37]. Massive parallel sequencing (MPS) has begun to be introduced, changing the technological platform of contemporary laboratories [38]. The potential benefits include increased speed of analysis, efficiency, sensitivity, and the depth of information gathered from the DNA sample, extending into investigative work [24]. More recently, law enforcement agencies have been able to extend the principals of familial searching to commercial genealogy databases, such as ancestry.com. The rapid increase in the size of genetic genealogy databases and cost-effective genotyping technology make genealogy searching attractive for law enforcement agencies [39]. However, concerns include the potential to uncover personal health-related information, such as a genetic predisposition for the development of a particular disease.

Forensic DNA analysis and litter

Three examples of the use of DNA analysis in relation to litter provide a stimulus for further critical analysis.

Non-human DNA analysis and litter

Human and non-human forensic genetics and genomics make use of the same advances in DNA sequencing [40]. Non-human DNA analysis in a forensic context may include the analysis of DNA from the inadvertent transfer of hair from a pet (or animal companion) or plant-based materials such as moss, mud and soil [40], which can be useful for identifying links between particular human offenders and/or victims to specific crime scenes. In addition to these existing capabilities in non-human DNA, technological advances allow for new developments, such as the genetic profiling of microbiomes (a community of microorganisms such as bacteria, fungi, and viruses that inhabit a particular environment), microbial metagenomics (the study of environmental microbial communities and the identifications of strains of microbiomes) and pathogens (bacteria, viruses, or other microorganisms that can cause disease) [40].

When it comes to litter, Langstone [41] highlights that animals, like

humans, have increasingly become the object of routine surveillance. She cites the example of PooPrints, a pioneering dog DNA registration scheme in London, which is designed to identify and hold pet owners accountable for uncollected dog droppings in public spaces [42]. PooPrints is an international commercial enterprise run by BioPet Laboratories. It offers a DNA waste management programme to solve pet pollution, and while it is already available in five countries to date, its greatest uptake has been across the United States, Canada, and the United Kingdom [42]. The services offered include a patented DNA World Pet Registry with more than 350,000 dogs registered, and the programme is being used by over 6000 private and public communities [43]. To register a dog on the Database, a sample of its DNA is first collected with a cheek swab and sent to the laboratories for analysis and profiling. BioPet Laboratories provide, on request, waste sample collection kits, which can be used to collect a sample (about the size of a coin) of dog droppings to return to the laboratories for processing. The unique genetic profile generated from the sample is then matched to the offending dog on the Pet Registry Database, which in turn identifies the owner of the dog [43]. Of course, the person responsible can only be located if the dog is registered and even a registered dog can defecate without consequence in areas outside those in which PooPrints is active.

Arguably, dogs are the one type of animal that is walked to a public location for the specific purpose of defecating [44]. Irresponsible dog owners may adopt a number of strategies to deal with the dog poo, such as ignoring the fact that the dog is defecating in a public space and is a problem that requires action, or wrapping the poo in a bag but leaving it on the ground or hanging it from a tree [44]. These approaches are likely to be unpopular amongst many users of these spaces, including more responsible dog owners who monitor and wish to protect public spaces from their own dog's poo [41].

However, the example of PooPrints raises important questions about the sort of society that we want to create and live in, including how we think that litter should be handled. While a resident who inadvertently steps in dog poo or who is confronted by dog poo on their property may see a benefit in measures to address irresponsible dog owners, PooPrints has the effect of placing dog owners themselves under surveillance via their pet dogs. In contrast to using public education and awareness campaigns, it presents dog owners with the threat of a sanction such as an advisory note warning of future enforcement activity or the issuing of a Public Space Protection Order (PSPO) [41]. Langstone [41] explains that the use of PSPOs "may be disproportionate instances of taking a 'hammer to crack a nut'" (p. 465). To put this into context, we know that although surveillance powers increased post 9/11, they were never intended to be used for misdemeanours. PSPOs are unprecedently open-ended powers that allow council officials to manage community members across a wide range of activities, including by banning behaviours such as dog walking [45].

Forensic DNA phenotyping and litter

Using the coding regions of the human genome, DNA phenotyping involves predicting external traits and characteristics of a person's physical appearance from their DNA [46]. This makes it possible to create an identikit of possible external features of a suspect without any eyewitness [47].

Exploring these advances in DNA analysis in 2012, artist Heather Dewey-Hagborg created an installation called *Stranger Visions* (https://deweyhagborg.com/projects/stranger-visions) using the DNA extracted from cigarette butts and chewing gum from the streets and public spaces in New York City. She employed DNA phenotyping and the programme, MorphFace, to create 3D-printed faces of the person who had discarded the items [48]. Interestingly, the reason that this installation used discarded items was not to create awareness of the problems around litter but rather, to create awareness of the emerging technology of DNA phenotyping [49]. In an interview, Dewey-Hagborg stated that "the point was to look at surveillance risks that were emerging that no one was talking about" [50 p. 4]. The artwork highlighted the community's expectations about protecting their genetic privacy, especially around DNA that was shed unintentionally into the environment [51].

DNA phenotyping has nonetheless been used in litter campaigns. In 2015, the international advertising and brand management firm, Ogilvy, created an anti-litter campaign in Hong Kong titled *The Face of Litter* (https://www.youtube.com/watch?v=HwL5HkEAo8k) [48]. In partnership with Hong Kong Clean-up and The Nature Conservancy, items of litter such as cigarette butts, paper coffee cups and used condoms that had been discarded in key public spaces were collected. Parabon Nanolabs used Snapshot DNA technology to predict externally visible characteristics associated with the unknown people responsible. The facial images developed were then printed on posters and displayed across the city and online [52]. While the campaign captivated attention, and predictive accuracy is discussed on the website, the portraits generated are relatively generic. Further, Parabon Nanolab's Snapshot technology depicts people at 25 years of age by default [53].

Highlighting the ambiguities of the facial images produced from DNA phenotyping, Dewey-Hagbog created a subsequent installation, *Probably Chelsea* (https://deweyhagborg.com/projects/probably-chelsea). The work celebrated the release of Chelsea Manning, a transgender female, who was incarcerated for leaking classified United States Defence information to WikiLeaks [50]. In 2015, from prison, Chelsea sent Dewey-Hagbog her DNA. Using the same technique developed in *Stranger Visions*, Dewey-Hagbog created two portraits of Chelsea, one showing an androgynous face and one a female face, highlighting the problems of simply reading gender based on genetic sex [54]. The algorithmic formulas used in computer generated facial identification rely on gender, with each gender having a different algorithmic calculation of the shape of the face, and placement of the eyes, nose, and mouth [48]. In *Probably Chelsea*, the uncertainty and subjectivity in the reading of DNA phenotyping, is pushed further with thirty algorithmically generated 3D images. Emphasising that one data set lends itself to multiple interpretations, Dewey-Hagbog [54] states, "these pictures presented as objective, neutral and certain, rely heavily on reductionist concepts of genetic sex and ancestry, and subjective renderings of how they appear" (p. 1). The faces generated are simply generic stereotypes, and if used for example in a litter campaign, have the potential to stigmatise an entire population of people based on stereotypes [49].

According to Gable Cino [55], the success of a suspect profile based on DNA phenotyping is subject to the success of the criminal investigation and this may profile or implicate innocent people, including minority groups. Social profiling based on predictive factors tends to expand the pool of suspects and widen opportunities for surveillance in ways that are frequently biased and racialised [56]. Again, a consequence may be the stigmatisation of select population groups and marginalised communities.

Covert sampling of litter for DNA

The analysis of DNA from litter has played a significant role in some serious criminal cases. The United States case of the Golden State Killer has been widely discussed as an example of investigative genealogy or genetic genealogy [57]. The case involved a violent serial offender, who was responsible for at least 12 homicides and over 50 rapes in California from 1974 through 1986. With investigative leads exhausted, police officers had the idea of submitting a crime scene sample to a genetic genealogy company to advance the case. The samples were sent to two separate companies and with the assistance of a genealogist, extensive work was done to draw up family trees of distant relatives [57]. Ultimately, the searches led to a former police officer, Joseph DeAngelo who lived in the area where the crimes had occurred. Placed under surveillance, police collected an item discarded by DeAngelo for analysis and comparison with the original crime scene profiles. DeAngelo was arrested and convicted [4].

The use of genetic genealogy could be summarised in stages. The first

stage is to identify a list of possible suspects. The list may be generated through familial searching of the criminal DNA database, and may be extended to commercial genealogy databases [58]. In addition, DNA phenotyping may be used to predict visible physical characteristics. In the second stage, the possible suspects are further investigated by the police, making use of usual investigative strategies to either eliminate or include suspects for further covert surveillance [59]. During covert surveillance, the suspect's trash and litter may be collected for the purpose of collecting DNA and generating a DNA profile for comparison with the crime scene DNA profile. The source or originator of DNA is seldom seen as its owner under current law in the jurisdictions of developed countries, meaning that we do not have any ownership or proprietary rights regarding our own genetic material [60]. The covert collection of 'abandoned' DNA associated with trash or discarded items is seldom regulated. For example, in the United States, it is typically unburdened by criminal procedure rules [61], allowing police officers relatively unfettered access to such DNA. If a match is found, the police then have probable cause and reasonable suspicion to request a DNA sample, and the DNA profile generated will form the basis of DNA evidence presented at trial [62]. The use of new technologies such as genealogy and phenotyping within police investigations generally falls beyond current legislative and judicial oversight [62] and requires appropriate policies that consider privacy and legal considerations [38].

Research suggests public support for the use of genetic genealogy for serious cases such as the Golden State Killer case. However, less support is associated with its use for crimes of a less serious nature [59]. More generally, public support for covert sampling of DNA from a discarded object has received relatively little attention. It may be that public support exists for cases that meet a certain threshold of seriousness [63]. It is unlikely that analysing DNA for a litter offence per se would meet such a threshold; many people would likely find that option to be manifestly excessive. Using forensic DNA analysis has always involved competing interests as well as economic costs and social benefits. On the one hand there is the individual's right to freedom, privacy, and autonomy, and on the other is the society's right to safety and security. These rights and interests have generally been subject to a degree of court scrutiny; however, with the advances in technology and the extension of forensic DNA analysis as an investigative and intelligence tool, there is a need to recalibrate these competing interests [57]. As Wienroth et al. [24] note, discussions of proportionality, and balancing diverse interests in pursuit of optimal outcomes, are of key concern. As technology becomes faster and cheaper, the need for such discussions becomes even more pressing. The continued development of biotechnologies along with their growing surveillance capabilities demand just and effective legal frameworks that, ideally, sustain a social order based on equality, liberty and democratic oversight [64].

Conclusion

Litter is a pervasive problem impacting the environment. This article has considered how DNA analysis may be used in various ways on DNA obtained from litter. While the potential of DNA analysis reflects advances in science and technology, and changes in policing to a more intelligence-led approach, various ethical issues arise from genetic surveillance that encompasses litter as a source of DNA for analysis. Two issues in particular stand out. The first is the linking of methods (e.g., DNA phenotyping) with the transgression (i.e., littering) in ways that appear to be disproportionate to the gravity of the offence and that may, unintentionally, institutionalise social bias (e.g., the targeting by the state of particular population groups, such as young people or people from ethnic minority backgrounds). Second, and related to this, the ease of application of the technologies (e.g., the growing availability and simplicity of sampling, and the advent of big data) also means that there is a level of potential surveillance and intrusion that has significant implications for privacy, human rights and individual autonomy. In many respects, these concerns mirror those of the artists TRES and Heather Dewey-Hagborg who, in using DNA analysis in representations of the harms of environmental pollution, simultaneously highlight the dangers and pitfalls of the new technologies.

Increased technological advances allow for easy access to a range of personal data from individuals. The use of data in law enforcement is no longer limited to a police officer's observations and records of previous police encounters. Contemporary big data extends to the constant collection and storage of electronic data, both through police encounters and by third-party providers that make use of technology that sifts through vast quantities of data for patterns of predictive behaviours, becoming familiar with our daily activities. Typical sources of such data are social media accounts, smartphone records, credit card activities, and internet search engines [65]. This shift in data collection provides law enforcement with access to new forms of intelligence, which on the one hand, may allow police to target, disrupt and prevent crime more successfully [4]. On the other hand, this shift also introduces threats to privacy and human rights.

As an example of the dystopian potential, the Chinese Government is trialling surveillance mechanisms such as voice samples, and facial and gait recognition technologies in some cities, allowing for constant surveillance of their citizens, most prominently those from marginalised groups [4]. Ferguson [65] describes these changes in the use of data as a shift from small data police intelligence to big data intelligence, which will impact all aspects of traditional policing. For example, Scudder et al. [66] explain that technological advances in the analysis process will see an increase in the use of forensic science, such as DNA analysis, as an investigative tool. Traditionally, DNA analysis aimed to identify and exclude suspects by comparing their DNA profiles with those of DNA found at a crime scene. However, familial searching and DNA phenotyping make it possible to generate suspects and investigative leads [25]. This amounts to extended police power and skews public safety in favour of state intervention over and above the rights of the individual. Policy makers who advocate environmental crime prevention on pragmatic grounds may well end up treating it simply as an administrative and technological challenge. To do so, however, is to ignore the social consequences of surveillance creep into previously protected domains of everyday life [67].

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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