

GRAFFITI VANDALISM AT CULTURAL HERITAGE ASSETS: REVIEW AND EFFECTIVENESS OF PREVENTION AND REMOVAL METHODS

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Abstract

Graffiti vandalism poses a huge issue for many urban centers globally, while heritage sites and individual cultural goods are not spared. The usual methods applied in the fight against graffiti vandalism relate to prevention and removal methods. This study has been undertaken with the aim of reviewing the existing scientific literature on this topic with the purpose of detecting types of methods used in solving this problem as well as evaluating their effectiveness/efficiency. Web of Science (WoS) records published until August 2024 were included in the review. The findings revealed that among prevention/removal methods, four types dominate: (a) chemical, (b) physical-mechanical, (c) biological (bioremediation), and (d) social methods. While all of them are effective, the selection of the method may vary depending on a number of factors (e.g., type of spray paint, substrate, cost, environmental effects, etc.). The pros and cons for each method are provided, which may serve heritage managers in the selection of a method as well as decision makers in creating an efficient policy framework related to the analyzed issue.

Keywords: Cultural heritage; Graffiti; Vandalism; Prevention and removal methods

Introduction

Graffiti is defined as a “form of visual communication, usually illegal, involving the unauthorized marking of public space by an individual or group” [1]. This form is usually associated with antisocial behavior and serves as a way of gaining attention, sometimes also as an expression of ideology, or simply serves as an adrenaline-seeking activity. Graffiti is also seen as an art form; however, this article deals exclusively with graffiti as a form of vandalism. Graffiti vandalism is defined as “the act of a person damaging or defacing any building, structure, road, tree, property, or other thing by writing, drawing, painting, spraying, or etching on it, or otherwise marking it without lawful authority, and without the consent of the occupier or owner or other person in lawful control” [2]. Although graffiti vandalism is very common, especially in urban areas on different types of public spaces, herewith it is of interest to research graffiti exclusively on cultural heritage assets. This type of vandalism causes substantial damage to heritage, destroying building facades, monuments, and other types of cultural goods with different inscriptions, pictures, drawings, etc., usually with spray paint [3]. It is a common problem both for individual heritage sites as well as for groups of buildings or even whole city districts; practically, there is no city that has not experienced graffiti vandalism. Thus, e.g., in the city of Zagreb, there are more than 3,500 illegal graffiti only in the city center [4]. The Government of NSW in Australia counts a total of 40,317 reported graffiti incidents in the period 2011-2016 [5].

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This poses huge challenges to city administrations since graffiti removal is extremely expensive and does not warrant that the perpetrators will not repeat their damaging actions. While recurring graffiti statistics are hardly available, graffiti on newly refurbished buildings are witnessed widely, which is not only an urban nuisance but also a frustration for both citizens and city visitors (e.g., the previous research showed that among the worst-rated elements in the eyes of the Zagreb tourists are graffiti) [6]. Examples of urban heritage aesthetic pollution by graffiti in the Zagreb city center are presented in Figure 1.



Fig. 1. Examples of urban heritage aesthetic pollution by graffiti (Zagreb city center). Photo credits: Anamarija Farkaš

The estimated economic damage worldwide of graffiti vandalism is huge: e.g., more than \$12 billion annually in graffiti cleanup in cities across the USA [7] is recorded. In the UK, the cost of yearly removal of graffiti is over £1 billion [8]; London spent at least £23 million in 2005 for removing graffiti [9], while the cost of graffiti removal in New York City was over \$2 million in 2021 [10].

The damage that graffiti can do to a heritage asset is difficult to measure in economic terms since it does not relate to the simple calculation of their removal but involves the damage

that it causes to the heritage values, as removals can leave a mark on the surface and thus damage the aesthetic but also educational, scientific, historic, cultural, and other values of heritage; therefore, its inherent values. On top of that, impacts of graffiti vandalism are seen to have economic (e.g., costs of removal, decreased property values, and decreased visits, alongside increased maintenance costs and insurance premiums), social (e.g., negative perception of the urban area, decreased heritage values, and antisocial behavior), and environmental consequences (related to chemicals used in graffiti removal).

This is why cities and heritage managers struggle in the fight against graffiti vandalism, both in removing it and in finding different methods in its prevention. A plethora of methods are applied, and the existing literature suggests that mechanical and/or chemical methods are the most often applied procedures, even though other physical removal methods can be adopted [11]. Besides physical removal, other methods are also available, but, to our knowledge, systematic research on the methods alongside their effectiveness/efficiency has not been done so far.

The goal of this paper is to review the existing scientific literature on the topic of graffiti vandalism on cultural heritage sites or cultural assets with the purpose of detecting types of methods used in solving this problem as well as evaluating the effectiveness/efficiency of the detected methods. Therefore, the two research questions are set: 1. What methods are used in solving challenges related to graffiti vandalism on heritage sites? and 2. What is the effectiveness/efficiency of the detected methods? The structure of the paper is the following: after this introductory part, which puts the issue addressed in the context and explains the goal of the research conducted, the methodology used is explained. It is followed by the presentation of the research findings, which are then further elaborated in the Discussion section.

Experimental part

Materials and methods

To determine and empirically assess the key advantages and challenges of the existing anti-vandalism methods, a systematic review of the academic literature was conducted in the period from April through September 2024. The review has been performed using the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) protocol. This method is used as a guideline for reporting the systematic review [12]. The database selected for the analysis was Web of Science (WoS) and included records published until August 2024. A Boolean search for the terms ('vandalism'* OR graffiti'*) AND ('heritage'*) was carried out, using the mentioned database. The analysis included research articles, proceedings papers, and book chapters in English. Exclusively vandalism at heritage buildings/sites was analyzed, which is why the "heritage" category was included in the search as a generic line of inquiry. Geographically speaking, the search was not limited but global. Thus, papers that involved the terms 'vandalism' and/or 'graffiti' but treated the topic of graffiti in other contexts than vandalism (e.g., graffiti as heritage, graffiti preservation, graffiti narratives, graffiti culture, graffiti as art, or vandalism in the context of conflicts) were filtered and excluded from the analysis. Also, duplicate papers were excluded. Thus, the initial number of records identified through the database search was 327, which were all initially screened. The first screen identified duplicate records as well as those that seemingly corresponded to the search but were then excluded based on the screening through the title and the abstract, which were found not to correspond to the area of our interest. 72 remaining records were assessed for eligibility. However, 21 of those records were additionally excluded since they (i) did not include all three Boolean search terms ('vandalism'* OR 'graffiti'* AND 'heritage'*), (ii) reported on another context of vandalism, or (iii) treated graffiti in another context (e.g., as art). The remaining number of records to be studied based on the full text was 51, as screened by the primary reviewer. Additional screening was done by the second reviewer to check if the process was done correctly, and the final number of records agreed to be included in the sample remained the same (51).

The process of the selection of the papers is presented in the following PRISMA diagram below (Figure 2).

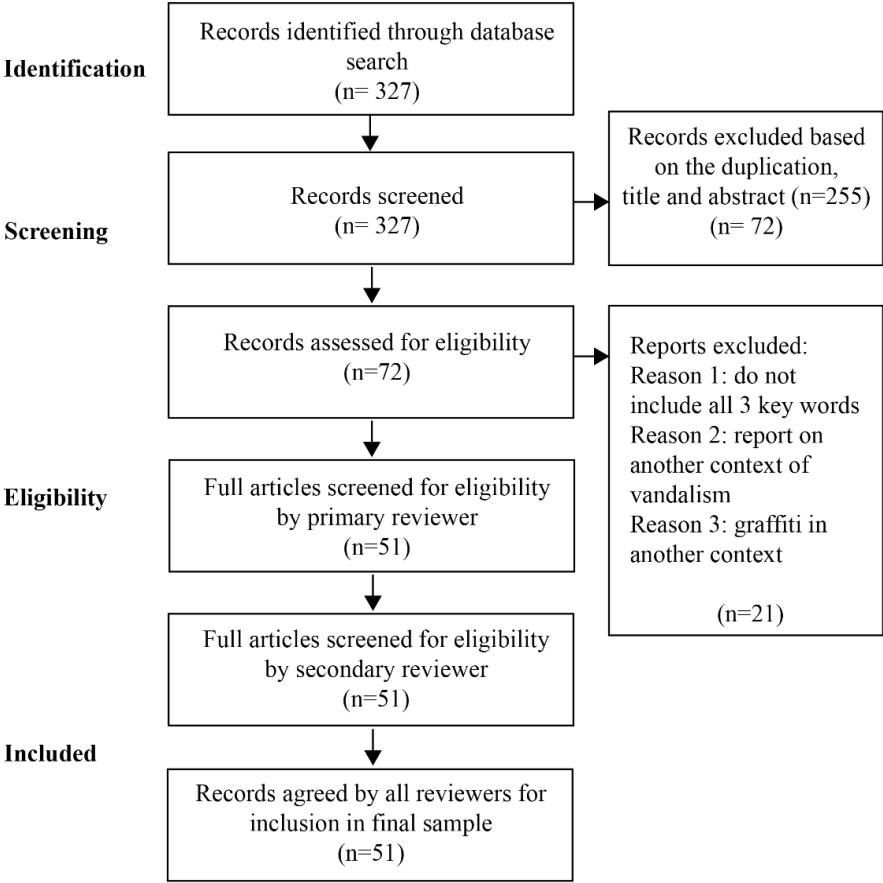


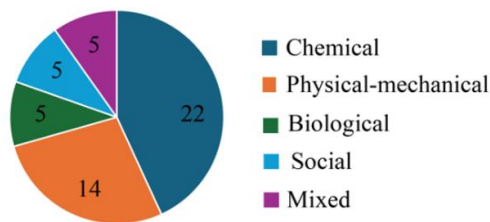
Fig. 2. PRISMA flow diagram; schematic view of search strategy

Results

The review results reveal that methods for dealing with graffiti vandalism on heritage sites are generally divided into (i) prevention methods and (ii) removal methods. According to the type, they can be categorized as (a) chemical, (b) physical-mechanical, (c) biological (bioremediation), and (d) social methods. Sometimes, a combination of methods is used in graffiti removal. The review analysis showed that 5 records analyze social methods, 22 of them are related to chemical methods, 5 records are focused on biological methods (bioremediation), 14 of them are physical-mechanical methods, and the remaining 5 articles describe mixed methods. Therefore, the largest number of records is the one analyzing chemical as well as physical-mechanical methods. Most of them (29) belong to the category of removal methods, which shows a reactive character in solving challenges to the graffiti vandalism at heritage sites. Only 5 records are dedicated to social methods, which may point to the lack of proactivity of heritage management stakeholders in charge of the issue or the research gap to be filled. Chemical methods are the only type of methods used both for graffiti prevention as well as removal at heritage sites. The type of methods and frequency of scientific texts on those methods in the reviewed records are presented in Table 1 and Figure 3.

Table 1. Types of methods detected in the reviewed records

Type of method	Prevention	Removal
Social methods	education, awareness raising, community involvement	5
Chemical methods	coating	12
Biological methods		chemicals 10 bacteria 05
Physical-mechanic methods		water jet lasers 14
Mixed methods		5

**Fig. 3.** Frequency of scientific texts on anti-graffiti methods in the reviewed records by type

Effectiveness/efficiency of methods

The analysis of the reviewed records showed that all the methods are effective but to a certain extent and to a varying degree. Their effectiveness/efficiency is dependent on several variables regarding the graffiti's inherent factors (e.g., type of graffiti spray used, type of substrate the graffiti was applied on), economic variables (cost-effectiveness of the method applied), environmental and human health-related impacts, etc. While the analyzed records provided little evidence on the effectiveness of the prevention methods, they might have an impact in the long run, yet this is yet to be established. Graffiti removal, on the other hand, is not easy, regardless of the existing methods applied. Thus, some chemical methods (e.g., paint strippers and solvents) demonstrate their efficiency in dissolving the paint on the stone but can possibly also be detrimental for such surfaces. Anti-graffiti coatings are used to prevent the penetration of the spray paint on porous surfaces such as stone and granite, while eco-friendly solvents are effective on sandstones [13]. Graffiti on marble and limestone is more easily removed with mechanical methods (e.g., dry soft-abrasive blasting), those on Carrara marble with water jets, while those on stone are usually removed with laser technologies. In terms of cost-effectiveness, the water-jet method proved effective on Ghiandone granite. Granite substrates were also found to respond well to some biological methods. Further on, the use of mixed methods has demonstrated an enhanced removal of the graffiti [14]. The following text presents findings of their effectiveness/efficiency by type.

The effectiveness/efficiency of chemical methods

The application of graffiti is done by different sprays, pencils, aerosols, or markers on substrates of different natures. These paints have pigments (e.g., soot, iron oxide, aluminum, etc.) that mix with synthetic resins (thermoplastics or thermostable). This allows the paint to bond with the surface, making it difficult to remove. This is why removal is often costly and is often not completely successful [15].

Chemical cleaning is the result of a reaction between the chemical product applied and the paint, with dissolution and/or extraction of the latter. Different organic and inorganic solvents are used as chemical products as well as hydrogels and nanofluids.

The effectiveness of chemical removal methods is often dependent on the graffiti spray used (there are hundreds of them on the market) and the type of surface vandalized by graffiti drawings (e.g., stone, marble, concrete, or granite), as well as the price of removal. Further on, chemical removal also depends on the weather conditions, humidity, and how long the graffiti has been on the substrate (the sooner, the better removal success). Evaluation of the effectiveness of graffiti removal by chemical methods is often best conducted using an optical microscope.

As mentioned, chemical methods of removing graffiti are very expensive, and although they may be effective, the fact has an important impact on the efficiency of their use. Further on, they do not fully meet the requirements for protecting the substrate or remove substances selectively, often with impacts on making damage on the stone surfaces and on the natural heritage asset patina. Besides, they are often not environmentally acceptable and may have risks for human health. Use of hydrogels and nanofluids in graffiti removal, however, seems promising since the toxicity and environmental impact of such cleaning systems are significantly reduced. For this purpose, these systems are water-based, and the amount of organic solvents is reduced to a few percent.

On the other hand, chemical methods are also used as prevention and applied as anti-graffiti coatings. The main types of coatings include sacrificial, non-sacrificial (permanent), and hydrophobic coatings. The first group is usually wax-based and allows the coating to be removed along with the graffiti. It is usually used in high-risk areas, and it provides only a temporary solution. The second group provides a longer solution, which needs no reapplication after graffiti is removed. Finally, hydrophobic coatings are suitable for outdoor settings since they repel water and liquids in general [16]. When it comes to the effectiveness/efficiency of the coatings, the analysis showed that there is not a universally effective one that would allow for equal effectiveness on all types of surfaces and for all types of treatments. Usually, coatings on smooth surfaces and less porous substrates are more effective [3].

The effectiveness/efficiency of physical-mechanical methods

Mechanical graffiti removal is done by way of hand tools or by machines. This usually entails laser blasting, dry ice blasting, water-jet brushing with water, hydro-pneumatic cleaning, controlled dry sanding (dry soft-abrasive blasting), low-pressure water projection, and low-pressure water spray [15].

When it comes to the effectiveness of these methods, results are available only for some of them. Thus, the benefits of laser cleaning for graffiti removal and its environmental friendliness must be weighed against the cost and longevity of the procedure. It is easy to install, control, and implement; however, it is not very efficient due to the high costs of its application. However, the laser ablation does not affect color changes and surface damages [17].

The water jet method is successful from a technical, economic, and ecological point of view, but it cannot be used on all types of stone due to the risk of damage.

The effectiveness/efficiency of biological methods

Biotechnology has proven to be useful in cultural heritage conservation. Such methods entail the use of different bacteria (microorganisms) in graffiti removal. They are usually called bioremediation, biocleaning, and bioconsolidation methods (with bacteria strains) and represent a novel approach to graffiti removal. This method overcomes well-known limitations of current cleaning methods. This removal method is not harmful to substrates, is environmentally friendly, and is safe for humans. Among different bacteria so far studied, the greatest success in bio-removal

of graffiti has been achieved with *Enterobacter aerogenes*, *Comamonas sp.*, and a mixture of *Bacillus sp.*, *Delftia lacustris*, *Sphingobacterium caeni*, and *Ochrobactrum anthropi* [18].

The effectiveness/efficiency of social methods

When it comes to social methods, they belong to a category of graffiti prevention methods. They include three types of actions: awareness raising, education, and community involvement. The last method usually relates to the involvement of the local community as the bearer of a heritage asset and may range from a simple reporting (often called “neighborhood watch”) to the full engagement of the local community. Education in schools, publicity about the impact of graffiti, and encouragement to report suspicious behavior in communities to authorities are all effective preventive measures. According to [19], “the best barrier is a community that has an emotional or economic link to the heritage. Engaging local communities in the management, conservation, and valorization of sites and ensuring that they are beneficiaries of the heritage lays the foundations of those protective barriers.” This entails participatory engagement of the local community. Additionally, novel approaches to tourist participation in the preservation of cultural heritage have also been put forward. Although they relate to different types of potential damages and not only those assigned to graffiti vandalism, they may also be applied to that matter. The method belongs to preventive preservation, although, to be specific, it is rather categorized as a detection method. Concretely, it uses several real-time photographs of the heritage object taken by tourists that are fed into a 3D model of the same object with the help of artificial intelligence. Experts use the system and check if any repairs of the object are needed. This saves them time (as they get real-time data, so early detection is possible) and money (no need for visiting the sites) [20].

The analyzed articles, however, are not many and prevent us from coming up with reliable data on the effectiveness of the mentioned methods.

The effectiveness of mixed methods

Few articles available in the analysis describe a combination of two methods (e.g., laser ablation and chemical removal) and generally state that the combination of methods is more effective, even if not always efficient in terms of its feasibility due to its high costs. An analysis of the effectiveness of the mentioned methods is presented in Table 2.

Table 2. Effectiveness/efficiency of anti-graffiti methods detected in the reviewed records by type

Type of method	Type of method	Effectiveness/efficiency of methods	
		Yes	No
Social methods			
1.1. Preventive methods	Awareness raising	-to a certain extent	
	Education	-to a certain extent	
	Community involvement	-if emotional and economic link to heritage is established and participatory approach to heritage management taken	
1.2. Detection methods	Tourist involvement in sharing photos of a heritage object	-early detection of potentially damaged items -real-time photos -cost-effective	
Chemical methods			
1.3. Preventive methods	Sacrificial coatings	-only as a temporary and quick solution -on smooth and less porous surfaces	-non-durable solution, removed along with the graffiti -on rough surfaces

Type of method	Type of method	Effectiveness/efficiency of methods	
		Yes	No
1.4. Removal methods	Non-sacrificial (permanent) coatings	-need no reapplication after graffiti is removed	
	Hydrophobic coatings	-for outdoor settings since they repel water and liquids	
	Organic and inorganic solvents	-effective to a certain extent	-often harmful for the surface -often unable to achieve a complete removal -environmentally unacceptable -may have risks for human health -costly
	Hydrogels and nanofluids	-reduced toxicity and environmental impact	
2. Biological methods	Bacteria strains	-not harmful to substrates -environmentally friendly -safe for humans -only some types of bacteria show satisfactory effectiveness	-not all the bacteria used - are equally effective -novel method
3. Physical-mechanic methods	Laser cleaning	-effective on the stone surface -easy to install, control and implement -environmental friendliness -no color changes and surface damages	-cost -longevity of the procedure
	Water jet	-economic effectiveness -ecological effectiveness -on the Carrara marble	-not for all types of stone -risk of surface damages
	Dry soft-abrasive blasting	-on limestone and marble	
4. Mixed methods	Combination of methods in general	-more effective than the use of just one method	-costly

Discussion

The results of the analysis of the reviewed articles detected two main groups of graffiti eradication methods: preventive and reactive ones. The first group entails approaches and activities aimed at reducing the number of graffiti incidents, while the reactive methods are related to several techniques of their removal. All the methods are grouped into four types of methods: chemical, physical-mechanical, biological, and social methods. Chemical methods are the only type that belong to both the prevention and reactive groups of methods. While social methods are all grouped in the preventive category, another subgroup of detection methods has been discovered, which does not warrant complete prevention but rather precedes graffiti removal. This answers the first research question. Putting it in the wider context, the results show that scientific elaboration of the existing methods is not complete, as other methods are also used in practice, e.g., improvement of lighting, improvement of natural surveillance, use of creepers where allowed, restriction of access, enforcement [2], monitoring techniques (including e.g., CCTV, graffiti paint detectors and sensors, drones) [21], etc. This points to another group of methods used in graffiti prevention—technology-enabled methods—but the analyzed articles did not report on that. Other existing methods related to physical barriers or legal methods are

considered as possible proactive and reactive graffiti vandalism-related measures to be taken by public authorities and heritage managers and should be further analyzed in that context in future research.

Effectiveness/efficiency of the methods detected in this review reveals that all methods have some effect, be they preventive ones or applied in the graffiti removal. However, no perfect method has been detected that would allow for its selection among a plethora of available ones. Effectiveness of methods is dependent on the context, which is related to the (a) inherent graffiti characteristics and a substrate the graffiti is on, (b) potential damage the method can do to a heritage object, (c) durability of the effect, (d) longevity of the procedure, (e) complexity in the application of a method, (f) its cost-effectiveness, and (g) its environmental and human health friendliness. Thus, it is not possible to say that one method wins over another; it is rather a weighing decision a heritage manager has to make, taking into consideration resources (human, organizational, financial, technical, etc.) at disposal. Although some of the methods detected in this review exercise reveal to have more pros than cons in their use, as they do not report many negative effects (or any at all) (e.g., bacteria strains, hydrophobic coatings, hydrogels, and nanofluids), this does not demonstrate that they are more effective than the other methods. The reviewed sample is evidently incomplete in terms of an overall analysis, as the analyzed records are very specific and selectively focus on some methods. This also points to the need for future research expanding the topic on different types of substrates graffiti are applied on as well as on the enhancement of individual methods according to their detected flaws. Finally, as much as all the analyzed methods show some degree of effectiveness, it does not mean that they are fully efficient, as some of them are rather costly or require a long time in their application. The application of mixed methods has shown greater effectiveness but may also be inefficient in terms of the cost. When it comes to social methods, only a few of them have been mentioned in the analyzed sample without proper elaboration, which is why no clear conclusions are possible on their effectiveness. The Hussein Mustafa, Al-Rousan, and Bala'wi findings [22], based on the New Zealand Government's [2] measures on the effectiveness of the engagement of the local community in graffiti prevention, are in line with good governance principles in heritage management put forward in other research [23] where participatory approaches in heritage management have been advocated since they not only entice citizens' empowerment and affect communities' well-being but also have strong impacts on the sustainability of cultural heritage [24]. "Concepts of inclusivity, shared ownership, sustainability, and safeguarding of cultural heritage" [25] are ensured when a participatory approach to heritage management is taken, which may also prove effective also in relation to graffiti challenges on heritage sites.

Although a simple answer to the second research question is not possible, the results of the review still offer some indications on the available methods studied and scientifically elaborated. However, removal methods, although (partially) effective in their primary purpose, are not efficient if not put within the larger policy-related context; graffiti may be removed, but if no prevention measures are taken at a heritage site, it is likely that it will be defaced again. Therefore, prevention methods should be taken into consideration, with a mixed-methods approach recommended. The future research may contribute to (heritage) policy measures in solving graffiti vandalism challenges.

Conclusions

Implications of the findings in this research may be of use to heritage managers as well as policy makers when deciding which methods in the fight against graffiti vandalism to apply. Thus, pros and cons for the analyzed methods may lead them to take the right decision.

A limitation of the research is seen in the application of the review method only on scientific records published in the Web of Science (WoS), thus possibly not involving the review of all methods of graffiti removal/prevention. This suggests that future research may involve the search through other databases in search of scientifically analyzed anti-graffiti methods. Free-hand Internet research suggests that other methods also exist, but they were not included in this review due to a lack of scientific evidence on their effectiveness and due to a preset methodology used in this study, which focused on the records in the WoS database. Also, the analysis shows that there is more room for the refinement of the existing research analyzed in this review exercise since some of the removal methods have been researched only on certain substrates, failing to include different surface materials. Finally, social methods for graffiti prevention should be studied in more depth in future research since the records analyzed herewith were surprisingly scarce and brought only some general conclusions on the methods. Deeper knowledge on the effectiveness/efficiency of the prevention methods may lead to quality and efficiency of public anti-graffiti measures and avenues to also be taken in future research. This will ensure sustainability not only of cultural heritage assets but also will have a greater impact on social, economic, and environmental sustainability for communities living in the heritage areas.

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