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COMMUNICATING OUTPUTS, OUTCOMES AND IMPACTS OF WASTE-RELATED RESEARCH: THE "EMERGE" CASE STUDY

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ABSTRACT

Communication, dissemination and exploitation of research findings is vital to maximise research impact. This is increasingly important as society faces sustainability challenges that require people to be educated about a broad range of issues spread across academic disciplines, and this is especially true of the waste management industry. Despite this need, effective approaches to communication, dissemination and exploitation can be challenging. This paper presents the EMERGE project as a case study, presenting the approaches used, identifying areas of success and highlighting areas for further improvement. This reveals a successful strategy to communicating with scientific audiences but highlights the considerable potential for improvements in the approach to communicating with the general public. New approaches to social media usage for research projects need to be considered, such as working with social media professionals, using a greater variety of apps and proactive collaboration with influential users/accounts.

1. INTRODUCTION

In an era of sustainability concerns and climate emergency, environmental education is of critical importance if the transition to a sustainable society is to be achieved. Environmental education is defined by the Tbilisi declaration (1977) as "a learning process that increases people's knowledge and awareness about the environment and its associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action." (Gillett, 1977). The United Nations' Educational, Scientific and Cultural Organization (UNESCO, 2021) has highlighted the key role that environmental education can play in encouraging sustainable development, by increasing public awareness and respect for nature. The research community can play its part in this by adopting effective strategies to science communication, dissemination, and exploitation of the research findings (Clark et al, 2016). It is therefore vital that the latest research relating to environmental and sustainability issues is communicated in the most effective way possible, and to the widest possible audience. This is particularly applicable for the waste management sector, as it links very strongly to the three pillars of sustainable development: society, environment, and economy. Effective strategies for communication, dissemination and exploitation of results are therefore essential components of future research projects.

This paper presents the approach taken to communication, dissemination, and exploitation of research findings by the European Union's Horizon 2020-funded project "Evaluation, control and mitigation of the environmental impacts of shipping emissions" (EMERGE). This EU project focuses on the impact of wash water discharges from exhaust gas cleaning systems (EGCS) as a waste-related case study. It explains the approaches taken to communication, dissemination, and exploitation of research findings, whilst evaluating successes and areas for improvement.

2. BACKGROUND

Science communication is the act of conveying scientific knowledge to diverse audiences, often with varying level of expertise (Garvey, 2014). This may involve communicating with other scientists, policy makers, relevant stakeholders, as well as the general public. This broad communication is critical if the research is to improve awareness among wider society and make a meaningful contribution to environmental education (Cox, 2013). Sci-

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ence communication creates a channel of communication between scientists and wider society, enabling research to provide greater impact (Lamb et al, 2018). In the past, this was mainly the responsibility of teachers, science writers, journalists, and outreach coordinators. However, scientists are now increasingly taking an active role in science communication themselves (Cooke et al. 2017).

Science communication uses a variety of methods, including traditional approaches such as publication in scientific journals, presentations and publications at conferences, seminars, or public lectures, as well as dissemination through printed and broadcast media. In addition, digital media is increasingly employed as a tool for science communication, encompassing email lists, digital newsletters, and social networking sites such as X (formerly Twitter), Facebook, Instagram, LinkedIn, and YouTube, as well as podcasting (Fox et al. 2021). Research can make an impact on policy through the distribution of policy briefs to governmental bodies and relevant stakeholders (Masset et al, 2013). These methods are summarised in Table 1. The most effective science communication strategies use a combination of all these methods to disseminate the results in a targeted way to different audiences (Dudley-Brown, 2019).

Dissemination of research allows the work to make a meaningful contribution to the discipline, influence policy and lead to evidence-based decision making. Ensuring these findings are available and visible to a broad audience creates opportunities for collaboration, new ideas, and innovation, as well as enhancing transparency and accountability (Dienlin et al. 2021). This is particularly important for research that receives public funding (Suber, 2012). Communicating research findings to the public and key stakeholders not only helps create trust in science, but also raises awareness of the issues involved (Weingart and Guenther, 2016).

TABLE 1: Methods used in science communication and dissemination.

Key approaches	Examples
Academic articles and presentations	• Journal papers • Conference papers and presentations • Seminars • Events
Direct communication with stakeholders, governmental bodies, and potential users	• Press releases • Policy briefs • Events • Collaboration with and feedback from stakeholders
Digital communication	• Social networking sites • Online Newsletters and email lists • Podcasting • Online distribution of media (digital versions of printed media) • Blogs • Websites • Members/stakeholder network enrolment • Online survey
Printed media	• Magazines • Leaflets • Posters • Booklets
Mass media	• Use of television, radio, magazines, and newspapers

Sustainable development requires complex decision-spanning social, environmental, and economic aspects. Research can no longer be siloed within academia and separated from wider society. This entails a complete change in how knowledge is consumed, eliminating barriers to information and fragmenting disciplines. Education for sustainable development (ESD) has been encouraged as a way to address this, with UNESCO (2021) stating that ESD "gives learners of all ages the knowledge, skills, values, and agency to address interconnected global challenges including climate change, loss of biodiversity, unsustainable use of resources, and inequality. It empowers learners of all ages to make informed decisions and take individual and collective action to change society and care for the planet." ESD has been highlighted as an essential tool for achieving the sustainable development goals by 2030 (UNESCO 2021).

As a further step beyond communication and dissemination, the exploitation of research enables a sustained impact after the project concludes. This may include the use of research findings in published literature, further development of tools, models and approaches created during the research, the implementation of the research via policy, and the incorporation of the research findings into education, such as via university and schools' lectures.

Despite the clear benefits and importance, challenges still remain in relation to the communication, dissemination, and exploitation of research. Overcoming these challenges is vital if the cutting-edge of research is to be translated into meaningful outcomes. International research projects such as those undertaken by the European Union require a clear approach; however, this is often difficult to achieve. To overcome these challenges, it is essential to conduct a detailed study of the successes and failures of existing approaches. By identifying paths to success and learning from failures, we can pave the way for effective solutions. There is a lack of publications that presents comprehensive examples of these strategies for other researchers to learn from. This will be explored in this paper in more detail by presenting the EMERGE project as a case study.

3. EMERGE PROJECT

EMERGE is a 4-year project funded by the European Union's Horizon 2020 research and innovation programme. It aims to systematically analyse the complex interactions between technological options for pollution reduction, pollutant emissions and dispersion, and the environment. This especially focuses on the effectiveness of exhaust gas cleaning systems (EGCS), or scrubbers, used on ships to reduce pollutants, and the impact the discharge of the resulting wash water may have on the marine environment. Open-loop scrubbers discharge wash water as a waste product directly into the environment. Closed-loop scrubbers store this wash water and need specialist facilities in ports to manage this waste. The EMERGE project therefore has a clear potential contribution to sustainable development and the wider waste management sector.

The EMERGE project's broad aims were, firstly, to comprehensively quantify and evaluate the effects of a range of potential emission reduction solutions for shipping in Europe, and secondly, develop more effective strategies and measures to reduce the environmental impacts of shipping. This research has been undertaken by a consortium containing eighteen partners from ten European countries, and a further five international partner institutes. This network was expanded by 136 stakeholders and thirteen advisory board members recruited in the preliminary stages of the project. Details are available on the project's website (https://emerge-h2020.eu/).

While the EMERGE project benefits from a large network, granting access to resources and stakeholders that may not be possible in smaller-scale research projects, its approach to communication, dissemination and exploitation can provide useful insight to projects of all sizes.

3.1 Approach to communication and dissemination

The EMERGE project has deployed a wide range of approaches to communication and dissemination, which targets a diverse range of audiences. The target audiences identified in the communication strategy are:

- The EMERGE consortium partners
- Academic, research and general scientific/engineering community
- Shipping sector and community
- End users
- Policy makers
- Education community
- General public

These audiences have been reached in a variety of ways. In particular, the academic, research and scientific/engineering community has been targeted primarily through the publication of academic journal articles and conference papers. This approach has reached many key audiences, notably the shipping sector and community, end users and policy makers. The academic papers produced by the EMERGE project have been specifically aimed at open-access journals, resulting in 43 papers published and 3 accepted for publication by end May 2024 (Appendix 1). At least another 30 papers are in preparation for publication in peer-reviewed journals. Utilising open-access journals ensures that the research findings are accessible to all the target audiences highlighted above. A total of 68 papers were presented at international conferences, with presentations also given at a wide range of international conferences, workshops, webinars, working groups and committees. A full list is available (Williams and Neophytou, 2024).

The EMERGE consortium agreed to produce eight 6-monthly newsletters and four annual press releases from the project. These were successfully delivered – on time and on budget - and are available to view on the website. The aim of the newsletters was to disseminate information about the project and its progress to a wide array of stakeholders as. It provided updates on past and upcoming project events, international events where the EMERGE Consortium participated or was planning to participate in, and project news. It was an important communication tool as it contributed to building support for the project from all target groups and the public. The project's first newsletter included the following sections:

- Short project description
- Project's Mission
- Project's Objectives
- Project's Scope
- Project Consortium
- Project News (i.e. the starting of the project and its kick-off meeting)
- Future events (in which the EMERGE Consortium will be participating)
- Join the EMERGE Information Network (invitation to stakeholders)
- The project's social media accounts
- EU disclaimer

The structure for the next newsletters remained the same by removing the introductory details of the project.

Press releases were intended to communicate the project's developments or announce important achievements. They were released annually and aimed to update the targeted group within EMERGE's Information Network stakeholders, along with the public, on the project's progress. The project's press releases included project research findings and selected outcomes (i.e. case studies outcomes) accompanied by a bespoke Infographic that depicted the scope and approach of the EMERGE project. Additionally, the press releases included case study maps showing the areas of sampling and measurements for each case study.

Numerous tools have been used to communicate and disseminate these findings beyond academic journals. The project website was used as an information platform with the aim of organising key project information for partners and visitors, including stakeholders, members of the public and scientists. In addition, the project has benefitted by utilising the EMERGE member's websites, blogs, and media channels to further promote the research. Project newsletters, press releases and a summary booklet have been created and distributed to subscribers (Figure 1). Posters, briefing sheets, leaflets, roll-ups, and presentations have been created for distribution/display at events and online. Eight short documentary videos have been produced and have been made available via social media and websites. A stakeholder's workshop from 2021 was recorded an uploaded to YouTube as a long video.

Project events were meticulously coordinated and organised, encompassing stakeholder workshops (e.g., EMERGE Stakeholder Workshops in March 2021 and February 2024), conferences (e.g., the 13th International Conference on Air Quality), as well as seminars (e.g., a collaborative seminar with the SCIPPER project, EMERGE's sister project, held within the framework of the Posidonia 2022 Exhibition). These gatherings provided EMERGE partners with the opportunity to showcase their findings and engage stakeholders. Additionally, project representatives actively

FIGURE 1: Illustrative examples of an EMERGE project press release, newsletter and summary booklet.

participated in various conferences, where they presented the EMERGE project and their work within its framework, thereby broadening its reach to academic and professional communities. Other outreach efforts encompassed diverse communication campaigns including radio and TV interviews, increasing the project's visibility. The results of the project have been incorporated into the creation of educational lectures and seminars aimed at students, along with relevant training materials.

The use of social networking sites is a key aspect of the communication strategy (Table 2).

Numerous forms of social media were used to reach difference audiences. LinkedIn was used to target a professional audience. Other forms of social media were used more generally with the public in mind as a target audience. YouTube was used only as a platform to host videos which were then be shared to the other social media platforms.

The hashtags and profiles tagged on X (Twitter) are also shown in Table 2. This highlights that the chosen hashtags are all specific to the issues investigated.

3.2 Approach to exploitation

The EMERGE project developed a comprehensive strategy to enable continued exploitation of the research findings after the project has finished, with the following aims:

- Use of the project's results and policy recommendations in national, regional, and international conferences, fora, and organizations
- Use of the project's findings in scientific journals
- Use and further development of the project's data and tools (decision support tool) available on the website
- Development of new lectures and seminars for presentation to students

The target audiences for the exploitation strategy are organisations, entities or individuals that can benefit from EMERGE's results were identified:

- The EMERGE consortium partners
- Academic, research and general scientific/ engineering community
- Shipping sector and community
- Other end users (local authorities, port authorities, regulatory bodies)
- EU and other international policy makers
- Education community
- General public
- Research funding agencies
- Experts
- Media groups

This strategy aimed to maintain the project website's availability, further disseminate project's results at conferences and forums, and sustain the availability of the social media/printed media posts created to communicate findings. Considerable efforts were made to provide input to key stakeholders and policy makers, including:

- National governments
- the International Maritime Organisation (IMO)
- HELCOM (Baltic Marine Environment Protection Commission)
- the OSPAR Commission (so named because of the original Oslo and Paris Conventions ("OS" for Oslo and "PAR" for Paris))
- the International Council for the Exploration of the Sea (ICES)
- the Baltic Sea Action Group (BSAG)
- and EU expert groups (i.e. the European Maritime Safety Agency (EMSA)).

TABLE 2: Social media channels, target audiences and content type.

Social media	Target audience	Type of content	Hastags/Tagged Profiles
X	General public, key stakeholders, local authorities and governmental bodies, marine/maritime/shipping organisations & companies.	Infographics, videos, links, pictures, news, documents.	#EuEMERGE #H2020 #Shipping #Marine #Maritime #MarinePollutionPrevention #INEA #scrubbers #MitigationScenarios #ShippingEmissions #EnvironmentalImpacts #EmissionReductionSolutions @EU_H2020 @EUScienceInnov @EU_Commission @EUSciComm @EU_MARE @EU_ENV @Transport_EU @inea_eu
LinkedIn	Scientific community, professionals from related areas, local authorities and governmental bodies, marine/maritime/shipping organisations & companies.	Infographics, pictures, videos, links, news, documents.	
YouTube	Not specified	Audio-visual contents that will be shared on other media and platforms	For example, "Tidelines" video: https://youtu.be/raDZvo8rF70
Facebook	Not specified	Infographics, videos, links, pictures, news, documents.	

This was also achieved via attendance at meetings and provision of policy briefs, as well as working directly with the shipping industry and producers of abatement equipment. This strand of the exploitation strategy was made possible by the large EMERGE consortium and may not be possible for smaller research projects; however, it illustrates very clearly the benefits derived from collaborative efforts.

The strategy aimed to achieve the short-term targets of maintaining a network of key experts via collaboration between consortium members and the use of professional networks such as LinkedIn and promoting and supporting existing online tools such as the website, social media, newsletter, and documentary videos. The mid- and long-term targets were designed to enable working with international groups and surveying project partners to identify further opportunities that have arisen from the EMERGE project.

3.3 Outcomes

Whilst the project was only completed at end May 2024, there is unmistakable evidence of success. The production of promotional and educational material is shown in Table 3 (and available via the website https://emerge-h2020.eu/), demonstrating that the most used approach has been the production of short videos to highlight the research findings. The second most used approach is the distribution of newsletters twice a year, aiming at providing updates on the project, news, publications, and future events. These newsletters were distributed to a global network of subscribers and were presented in the form of short and succinct documents with a focus on conveying key information effectively, with a range of 2 to 10 pages, with the majority falling between 3 and 5 pages long. This prevents recipients being overwhelmed with too frequent and too long newsletters and losing interest. These newsletters have encouraged further exploitation of the research findings by highlighting publications produced by project partners and published to peer-reviewed journals. This communication strategy makes a direct contribution to the exploitation plan.

This strong focus on videos has been highlighted in the literature as an effective tool for science dissemination, particularly for use in the education sector as an effective tool for helping non-specialist users understand scientific knowledge (Giron-Garcia and Fortanet-Gomez, 2023). The policy briefs due to be created will also help implement the exploitation plan. Table 5 highlights a preference for digital dissemination over printed and physical media. This is essential for an international research project such as this and allows the research to reach a wider audience.

Eight short documentary videos have also been produced, with one video per work package. These videos have been distributed on the project's social media channels and may make a valuable contribution to communication and dissemination. In addition to this, the stakeholder workshops have been recorded and are available via YouTube (e.g. https://www.youtube.com/watch?v=dQrdnYvt360).

The total numbers of people reached using all dissemination and communication activities according to internal mid-term review reports from the EMERGE project are shown in Table 4, also highlighting areas of success.

The high number of over 129 million members of the general public reached is according to project partner Chalmers, with their press release reaching approximately 129 million people. The press release received significant attention from global media outlets, earning it a spot-on Chalmers' top-ten list for widespread coverage. This highlights the importance of multiple avenues to reaching the

TABLE 3: Outcomes of dissemination strategies.

Approach	Quantity
Briefing note distribution	1
Roll up banner	1
Flyers and posters	1 of each
Newsletters	8 (2 per year)
Press releases	3 (1 per year)
Videos	1 project introduction, 8 short documentary videos and 2 long recorded stakeholder workshop videos from 2021 and 2024.
Policy briefs	Summary booklet published, briefs due at project end.

TABLE 4: Type of audience reached by dissemination & communication activities according to mid-term reports as of March 31st, 2023.

Type of audience reached in the context of all dissemination & communication activities (as of 31st of March 2023)	Estimated number of persons reached
Scientific community (Higher education, research)	7202
Industry	5052
Civil Society	983
General Public	129,007,442
Policy Makers	1795
Media	145
Investors	732
Customers	732
Other	1177
Total	129,025,260

general public, with press releases able to make a significant contribution.

The approach of the EMERGE project to publishing findings has clearly been successful, leading to 43 academic papers published to date, with a further 3 accepted for publication, against an overall target of 50. In terms of achieving the objectives of the exploitation plan relating to use of the projects results and findings, Overall (by end May 2024), the papers have been viewed close to 50,000 times, downloaded more than 11,000 times, and cited over 500 times. The exact counts for views and downloads will be higher as not all journals provide detailed information about downloads and view counts.

These results produce a mean citation count per paper of 14.6 citations (at the end of May 2024), which suggests the work has been highly impactful thus far, especially considering many of the papers have only been available for two years or less. The use of open-access journals has made the research papers more accessible to a larger audience and has contributed to achieving the exploitation plan. Young and Brandes (2020) found that open-access papers receive more citations and attract a more diverse, interdisciplinary audience, which is beneficial for research aiming at producing more sustainable outcomes, as it necessitates consideration across various disciplines.

The number of attendees at stakeholder workshops was 140 at the online stakeholder workshop in 2021 and 66 at the online stakeholder workshop in 2024. These events enabled the EMERGE project's progress and results to be disseminated to a range of stakeholders in multiple countries. A bespoke EMERGE EU stakeholder workshop was initially planned to be held in a hybrid format, with both in-person participation in Brussels and online attendance, scheduled for May 2024. Participants were representatives from the EMERGE project, the EMERGE EC Project Officer, and stakeholders from parent DGs, CINEA, and EMSA. The agenda, detailing arrangements for both in-person and online participation, along with the WebEx invitation for the online attendees, were sent to the EC Project Officer for dissemination to EU stakeholders prior to the event. However, due to the Project Officer's inability to attend the event in person, and at their suggestion, the format was shifted to an entirely online event.

Prior to the workshop, the EMERGE e-booklet was distributed to EMERGE partners and the EMERGE EC Project Officer for further dissemination to EU stakeholders. This e-booklet provided a comprehensive overview of the project's key accomplishments, including scientific achievements, policy recommendations, and guidance. The EMERGE EU stakeholder workshop took place online on May 21, 2024, and lasted approximately three hours. During the event, project results and policy recommendations were presented to 30 attendees, including the EC Project Officer, one stakeholder from EMSA, one from DG MOVE, and the EMERGE team. The event was recorded, as per the EC Project Officer's request.

An innovative dissemination activity was a creative collaboration between the EMERGE team, three university faculties, the University of Southampton's (UoS) Widening Participation and Social Mobility (WPSM) team, three schools based in Southampton, England, and a local professional artist. The goal of "Tidelines" was to promote knowledge exchange on nature- and engineering-based solutions to climate change and decarbonisation in the marine environment based on the findings from the EMERGE project.

A knowledge exchange (KE) programme was developed to inform international policy-making and future, sustainable, collaborative projects that support levelling up and Equality, Diversity & Inclusivity skills & capability development in disadvantaged communities. This was achieved in February-June 2024 by combining science/engineering and the arts to inform, inspire and encourage engagement in solutions to contemporary issues that affect coastal communities.

"Tidelines" is an innovative multimedia project that placed international researchers, professional poets, and student poets ('Shadow Poets') in targeted youth settings in Southampton, primarily disadvantaged young people in the IntoUniversity Southampton West partnership. EMERGE researchers interacted with primary and secondary school children to discuss the complex interactions between shipping and coastal environments. There was a focus on discussing sustainable solutions to societal impacts, technological options, pollutant emissions and dispersion, and environmental costs/benefits. Additional benefits included the development of improved literacy, self-confidence, and a range of soft skills in the children. University- and Student Poets led research-based and creative workshops to inspire young people, teachers, and teaching assistants (TAs) to write and perform poetry about i) their current everyday lives in a coastal city and ii) how they feel nature- and engineering-based solutions could transform coastal areas for the better. The workshops culminated in a performance and interactive iBooks that featured poetry, audio, and videos created by the participants. The outputs will be hosted on the EMERGE project's website to ensure international communication/dissemination and input into policy-related discussions (Figure 2). We led pedagogical and practical training with the teachers and TAs, focussing on

FIGURE 2: Screenshots from the Tidelines video featuring the rap "Listen Up Businesses" created by the school children as their response to what they learned from the EMERGE project's findings.

Action Competences, speedy filmmaking techniques and iBook creation. The iBooks of poetry were be written and performed by the young people, the teachers, and the Shadow Poets. One iBook from each school and an anthology of selected poetry from the entire project will be freely available to download. Each interactive iBook contains poetry in accessible written, audio and video form. A final celebratory showcase event was held involving each school. The showcase celebration featured original poetry videos from the project, performances from the Young People and Shadow Poets, and launched the iBooks. The EMERGE project team will include the outputs and outcomes in their recommendations to international marine/maritime organisations.

Appendix 1 and the data above shows that the EMERGE project has successfully communicated its findings via peer-reviewed academic journals and clearly reached an academic and professional audience. This effective communication with professionals can be seen in the social media accounts, with LinkedIn performing the best, exhibiting a greater number of likes and comments than X, Facebook and YouTube combined, as shown in Table 5.

These statistics suggest that the EMERGE project has succeeded in communicating with other scientists and professional stakeholders. However, the lack of interactions on social media accounts targeting a broader audience indicates that, concerning outreach to the general public, the project has been eclipsed by e.g. immediate news stories, entertainment, and content from celebrities and so-called influencers. This remains a challenge for the scientific community but may be partially addressed by further work as the project comes to its end and all the outputs, outcomes and impacts become available. The exploitation plan will further increase the interaction with the general public after the project has finished.

Table 5 highlights that despite considerable efforts to build a considerable social media presence, with over 1000 posts overall, this has led to little interaction, with an average interaction of only 6.8 likes and comments per post. If likes and comments of those directly involved with the project were removed, this average would drop even further. This poses the possibility that if the interactions of those directly involved were not included, the actual interaction

TABLE 5: Interactions with social media accounts. Accurate 29.05.2024.

Social media	Followers	Number of posts	Total Likes and comments	Average likes and comments per post (mean)
X (formerly Twitter)	141	118	614	5.2
Facebook	123	94	510	5.4
LinkedIn	761	88	1508	17.1
YouTube	18	11	9	0.9
Overall	1,043	311	2,641	7.15

with the general public via social media may be negligible. This, however, does not necessarily reflect a failure of the EMERGE project, as other industries aiming at public engagement have also been shown in the literature to receive similar levels of interaction on social media (Roberts et al. 2021), and the EMERGE project is a project most useful to policymakers rather than the general public. A social media engagement rate of 1-5% is considered to be a good rate, although this becomes harder to achieve as the number of followers increases (Sehl and Tien, 2023). The average likes and comments per post shown in Table 5 reveals an average engagement rate of 3.7%, 4.4%, 2.2% and 5%, for X, Facebook, LinkedIn, and YouTube respectively. Thus, despite these numbers appearing to be low, they are still good engagement rates for social media.

The short documentary videos uploaded to YouTube further highlight the challenges. These provide an introduction, 7 videos for different work packages, and then a summary video. These videos have 47 views on average and 0.5 likes on average. Two key issues that are present in the YouTube approach are the names of the videos, which are named after the work packages, such as EMERGE WP1, WP2, etc, and the fact comments are turned off. These names make the videos difficult to find for the general public, who may use generic search terms such as "the impact of scrubbers" rather than searching for specific work packages. Having comments disabled also prevents interaction and may make the videos less visible, due to social media algorithms prioritising content with high levels of interaction. If interaction is disabled, then the videos are always going to struggle to be seen. The EMERGE project has used YouTube simply as a site to host videos and then share them on other platforms, which is where the main interaction with these videos is to be found.

Another aspect to consider is the information that viewers receive even when they do not directly interact with social media content. Chung et al. (2020) found that when social media was used for environmental education, viewers often did not interact with the posts or share them, but they did still acquire environmental information. This suggests that evaluating the effectiveness of social media simply by interaction levels may be ineffective, as it will fail to capture the exchanges of information that still take place. This highlights the challenges of science communication and despite its benefits, social media's effectiveness is difficult to evaluate. Whilst scientists have taken an increasingly active role in science communication, and digital communication has become an increasingly widely used tool for science communication, the complexity of social media and the algorithms involved may mean that a lot of effort from the scientists may lead to little actual measurable public engagement. Posts on social media that are successful are often referred to as having gone viral, where the post amasses significant interactions in a short space of time. The reality of social media is that the vast majority of posts fail to take off in this way and achieve little interaction (Sehl and Tien, 2023). In order to go viral a post needs to satisfy the requirements created by an algorithm that then decides to what extent the post is prioritised, filtered, ranked, and recommended to other users (Poyry et al, 2018). This makes using social media an art in itself. The rise of social media has led to the era of influencers and those who make a career using social media, attracting vast numbers of people to their content, and generating enough revenue to make a living. This shows that social media can be highly effective if used correctly and the potential for public engagement is vast, but identifying these strategies is challenging.

The social media sites of X, Facebook and YouTube may limit the reach of the research, with apps such as TikTok, Instagram and Snapchat proving more popular with young people (Hogan, 2022). This may be because apps such as TikTok have rapidly become popular during the years that this research project has taken place. This suggests that future research projects should consider using new apps as they emerge. For example, Ofcom (2023) found that TikTok was the most favoured source of news for teenagers in the UK, followed by YouTube and Instagram. Research investigating the potential role of TikTok in science communication has found that it was a useful platform for providing summaries of research papers in video form, and that 84% of users felt higher levels of trust in science and scientists after following (Rein, 2023). TikTok may represent a useful tool for this and other projects to use in the future to distribute short documentary videos.

The EMERGE project has only posted 11 times on YouTube, and has mostly focused on X, Facebook, and LinkedIn. X and Facebook both have declining user numbers and are less popular with young people (Canales, 2021), and LinkedIn is largely a professional network. This means the reach of this project is limited in regard to the general public and future projects should consider a more diverse range of apps for disseminating the findings if young people are to be more effectively included. Another option to increase the reach of social media posts would be to pay to advertise, which is something most businesses actively do on social media already (Fulgoni, 2015). If academic work is to achieve the same visibility it may have to be promoted in the same way and invest some of the budget assigned to communication and dissemination, if any exists, into actively promoting the work on social media via paid advertising and/or collaboration with influential users. Artificial intelligence (AI) is likely to become a useful tool in helping make engaging social media content in the near future.

The hashtags identified in the communication and dissemination strategy are shown in Table 2. However, in reality, the majority of posts on the X account contain no hashtags, reducing their potential reach. Whilst these chosen hashtags may have been useful for engaging with key stakeholders, government authorities, maritime industries etc, one issue of using these highly specific hashtags is that it is not going to engage the general public. These hashtags will be followed by those with an existing interest in shipping and maritime issues, rather than those with a general willingness to learn who may follow more general hashtags relating to the environment, science, and sustainability. The largest potential audience on social media is those who are not already actively engaged with the accounts, however with these hashtags there is no obvious

way to engage them, as most of them are very content specific. One way a project could improve its exposure to the general public would be to use more general hashtags broadly relating to the issue presented, such as #environment #sustainable #sustainability #green #ecofriendly etc. (Matthews, 2011).

Another issue which will impact the EMERGE project's online visibility is the fact that another European Union Horizon 2020 funded research project shares the same name; the evaluating mHealth technology in HIV to improve empowerment and healthcare utilisation: research and innovation to generate evidence for personalised care (EmERGE). Whilst it is inevitable that similar names may be used over time, it makes it more difficult for the project website and associated social media accounts to stand out, which may have a detrimental impact on long-term legacy exploitation.

4. CONCLUSIONS AND RECOMMENDATIONS

The approach taken by the EMERGE project demonstrates a successful example of science communication, dissemination, and exploitation. A large number of academic articles have been published and there is a large social media presence. Rapid publication of results has allowed the research to be well-cited before the project has even finished, leading to a highly impactful research output. This highlights the importance of prompt publication of research findings and the benefits of publication in open-access journals. The large consortium of members and wider stakeholder network has ideally positioned the EMERGE project to implement its exploitation plan successfully. For smaller projects that lack this network, collaboration should be encouraged wherever possible to expand the potential strategies available.

The project has reached the public successfully via press releases which were communicated by the media, with over 129 million views. One aspect of the strategy that could be elevated further is a potential lack of engagement with the public via social media, which is a common issue with public engagement approaches. The EMERGE project outcomes are most useful for stakeholders, and there is a limit to the impact the general public could have on encouraging the implementation of research findings, however, this will not be the case for many other waste-related and sustainability-related research topics. Improving engagement with the general public will be highly important if these projects are to be translated into behavioural change.

Social media represents the most widely used tool used in the approach to engaging with the public, and it is possible that if interactions from consortium members were to be removed from social media, there may be a low level of engagement. The documentary videos may also fail to reach the public due to the names assigned to these videos. Whilst this issue is not unique to the EMERGE project, it illustrates that even large projects can still struggle to engage with the public. To address this, science communication strategies should consider an innovative approach to social media use. Further research could attempt to identify the most suitable strategies to increasing social media engagement, which may potentially include approaches such as paid advertisement, collaboration with influencers/successful accounts, better use of titles and hashtags, employing social media professionals, and content designed with social media algorithms in mind.

A greater variety of social media apps could be used to better reach the general public, especially young people who prefer apps such as TikTok, Instagram and Snapchat which are less frequently used for science communication. Podcasting could be used to increase the impact further. These tools may also be easier to use for smaller projects that lack a large stakeholder network.

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