Environmental Science Advances

ROYAL SOCIETY OF CHEMISTRY

PAPER

View Article Online
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Cite this: *Environ. Sci.: Adv.*, 2025, **4**, 1267

The resonance of messages about wastewater reuse: recommendations for environmental communication

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Numerous studies have examined the factors influencing public perception of the reuse of treated wastewater and have consistently identified sensitivity to contamination and feelings of repulsion as the most significant barriers to acceptance. However, far fewer studies have examined the positive arguments that can promote the acceptance of reuse of treated wastewater. This study investigates how individuals cognitively respond to media messages on this topic by testing the cognitive resonance of four news-like messages with different framing manipulations ($N = 1040$ adults). Depending on their framing, these messages elicited more or less negative responses from individuals concerned with pollution and personal health compared to those focused on sustainability and environmental benefits. These findings highlight the importance of tailoring communication strategies to different audience profiles. The recipients' responses also underscore why scientists, particularly chemists, need to adopt communication approaches that may feel counterintuitive to them in order to be persuasive. Based on these findings, this study suggests ways of designing messages that can effectively promote the reuse of treated wastewater among resistant social groups. Finally, broader lessons for environmental communication are drawn.

Received 13th March 2025
Accepted 24th June 2025

DOI: 10.1039/d5va00065c

rsc.li/esadvances

Environmental significance

Different social groups interpret environmental messages about wastewater reuse in significantly different ways. Individuals' interpretations of media messages about treated wastewater reuse are strongly linked to their acceptance. The effectiveness of threat-based messaging in wastewater reuse communication depends on the social attitudes and dispositions of the target audience. Resonance analysis provides a foundation for developing arguments that can mitigate fear and disgust when communicating about pollutants.

Introduction

In 2018, 2020, 2022 and 2023, Europe faced prolonged and severe droughts, leading to restrictions on drinking water supplies, reduced crop yields, crop failures, damage to vegetation and ecosystems, suspension of industrial activities and restrictions on navigation.[1] Drought-related economic losses have affected agriculture, the energy sector and public water supplies, with damages reaching up to €9 billion per year. With projected global warming of 3 °C, droughts are expected to become twice as frequent, potentially increasing annual drought-related losses in Europe to €40 billion.[2]

As a result, water reuse and the reclamation of treated wastewater have been identified as critical priorities in the transition to a sustainable and resilient water system. Currently, most treated urban wastewater is discharged into rivers. Reusing this treated wastewater for agriculture, industry or households can close the water cycle, creating a circular water economy and increasing resilience to drought and water scarcity for households, nature, industry and agriculture.

The use of treated wastewater for groundwater recharge and irrigation also offers several chemical benefits that are particularly relevant for water quality and resource management in the context of drought and climate change.[3] Treated wastewater can serve as a source of essential nutrients such as nitrogen and phosphorus, which can improve soil fertility and enhance plant growth. The organic matter in treated wastewater can stimulate beneficial microbial activity in soil and groundwater, improving overall ecosystem health. As treated wastewater percolates through soil and rock layers, it undergoes natural filtration processes that reduce concentrations of certain contaminants, improving water quality. In addition, the chemical composition

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of treated wastewater provides buffering capacity that stabilises groundwater pH levels, which is critical to maintaining a suitable environment for aquatic life and preventing chemical imbalances. Finally, the recharge process can dilute naturally occurring contaminants in groundwater, such as heavy metals or salts, improving overall water quality and making it safer for various uses.

Despite these benefits, recharging groundwater or irrigating with treated wastewater also poses significant chemical hazards that require careful management.[4,5] Inadequately treated wastewater can contain harmful pathogens such as *E. coli* and viruses, posing serious risks to human health and environmental integrity, especially when groundwater is used for drinking water. Treated wastewater may also contain persistent chemicals, including pharmaceuticals, personal care products and endocrine disruptors, which can have long-term ecological and health effects. The interaction of wastewater contaminants with natural constituents in aquifers can lead to the formation of toxic by-products, further complicating water quality management. Trace metals such as lead, cadmium and mercury can also be present in treated wastewater, posing a risk to both groundwater and surface water systems.

When groundwater containing these contaminants is discharged into rivers, lakes and wetlands, it can harm aquatic organisms, including fish, amphibians and invertebrates. Toxic compounds, including trace metals and persistent organic pollutants, can accumulate in the tissues of aquatic organisms and move up the food chain to affect larger predators, including birds, mammals and humans. In addition, the presence of pharmaceuticals and organic contaminants can disrupt microbial communities in groundwater and surface water systems, affecting natural biogeochemical cycles and nutrient cycling.

Unless these environmental risks are mitigated, it is clear that wastewater reuse will not be accepted by environmental regulators or the public. However, even when all the necessary water quality assurances can be provided, public perception may still be a major barrier to the acceptance of water reuse. As the literature reviewed in this article shows, effective communication is essential to address deep-rooted fears and negative perceptions that could hinder social acceptance and provoke political opposition.[6,7]

Scientists are often called upon to provide information on a topic, but they may be ill-equipped to communicate effectively. This is not just a matter of following good or best practices that can be remedied by formal communication advice. Communicating effectively—whether to raise awareness, influence attitudes, or promote behaviour—requires a mindset or cognitive style rooted in an understanding of how non-scientists reason.[8,9] For example, in the case of wastewater reuse, as this study demonstrates, the mere mention of pollutants by name (as in the preceding paragraphs) can be enough to deter people from reusing wastewater.

This study therefore explores how and when the perception of risk and threat influences public perception and how it can be countered. Using an experimental design, four groups of participants ($N = 1{,}040$) were exposed to a minimal information condition and three self-constructed news articles addressing the risks of wastewater reuse while presenting carefully crafted arguments in favor of it. The study focused on an innovative water reuse project on farmland in northern Belgium (Kinrooi, Flanders), where artificial irrigation systems were installed.

To analyse the reception of media messages, a self-developed methodology called resonance analysis was used. This approach explains how different groups of people draw on distinct associations of thoughts and feelings to interpret and respond to media content. The methodology is grounded in a neuropsychological and sociological theory of media reception, which posits that the interpretation of media messages arises from the interaction between the representations of reality contained in the message and pre-existing cognitive patterns—or prior representations—stored in the recipients' memory.[10]

This paper begins by examining the crux of public perception regarding wastewater reuse: fear of contamination and the communication challenges this presents. The next section discusses an approach that suggests communication can be effective when the communicator actively addresses people's fears. We then examine other research that explores additional elements of environmental communication strategies for wastewater reuse, focusing on creating a sense of control and promoting positive outcomes. The remainder of this paper covers research methods, the description of the findings and a brief discussion. The last section presents recommendations for communicating about wastewater reuse. In conclusion, some general suggestions for environmental communication are formulated.

The research presented in this paper is the result of an interdisciplinary collaborations between chemists, geological engineers and social scientists, working together to better communicate about real-world wastewater reuse projects. This study aims to be of practical value to scientists, water reuse planners and policy makers in developing strategies to communicate more effectively with different audiences and to navigate between oppositional and supportive public responses to wastewater reuse.

Public perception of treated wastewater

Wastewater reuse is becoming an increasingly critical aspect of modern water management, even in countries that do not yet experience but anticipate prolonged periods of water stress. However, authorities often face strong public resistance, as some people remain reluctant to accept alternative water sources.[11–14] Several studies have identified key contextual factors that influence public willingness to adopt water reuse, including perceived water scarcity, perceived benefits, trust in science and public institutions, knowledge, and environmental concerns.[15–19]

A common response in this context is that these problems can be resolved by providing accurate information. Numerous studies emphasize that providing information to the public is

essential for addressing the knowledge gap about wastewater reuse and overcoming resistance, which often leads to community opposition.[20–25] This seems like a logical approach, especially from scientists and public institutions in countries with robust systems for measuring and monitoring water quality. However, despite the availability of rational and scientifically sound arguments in favour of implementing water reuse schemes—particularly those involving high-contact uses such as drinking water and agricultural irrigation—an informed public does not always translate to a supportive one. Studies show that providing more or better information alone is insufficient to foster acceptance, as wastewater reuse triggers deep-seated emotional resistance. Even in industrialized societies, where extensive efforts and assurances are built into water monitoring systems, fear of contamination and associated feelings of disgust remain the most universal and significant barriers to wastewater reuse acceptance.[26–31]

For environmental communication scholars and experts, this represents a major challenge: How should we communicate with people in such a way that they are convinced to consume something for which they have deep-rooted fears and aversions? One study suggests that priming environmental concerns can help reduce resistance to wastewater reuse, but this effect strongly depends on how the advantages and disadvantages are presented in the message.[32] An experimental framing analysis of wastewater reuse information—manipulating both the positive and negative connotations of terminology and accompanying photographs—found that positive wording can enhance acceptance of potable wastewater reuse. However, this effect is strongly mediated by individuals' risk perceptions.[33]

Complicating matters further, another study on the effectiveness of communication messages about wastewater reuse has found that the impact of arguments can vary depending on both the content and structure of the messages. This variation may be due to the complexity and the sidedness of the messages—that is, whether they present unilateral arguments (only positive aspects) or bilateral arguments (both positive and negative aspects of recycled water).[34]

Overall, this literature suggests that public responses to messages on wastewater reuse can vary both cognitively and affectively, depending on how messages are communicated, framed and presented. Furthermore, this type of research highlights that 'the public' is not a single entity but consists of diverse groups, each engaging with the subject and its implications based on their unique experiences and concerns.[32,34] Reactions to different messages may thus differ in terms of content and intensity, shaped by people's cognitive and affective predispositions.

This underscores the necessity for research designs on communication about wastewater reuse that account not only for the diverse composition of media audiences, with each subgroup processing information based on pre-existing cognitive and affective dispositions, but also for the varied ways in which the same topic can be communicated, framed and presented. The central question in this discussion, however, remains how best to address the fear, or at least the ambivalence, that many people have toward wastewater reuse: should we confront the fear directly or circumvent it? In the following sections, we will explore two different approaches.

Instrumentalising fear

A communication approach that has recently gained popularity and suggests that fear can be an effective starting point for public communication campaigns on topics that that are often misunderstood, is 'inoculation theory'. This theory aims to provide tools to combat misconceptions about scientific topics in various domains, including healthcare and climate change, by instrumentalising fear.[35–37] The concept of inoculation draws an analogy with medicine, suggesting that exposure to a weaker cognitive challenge can build resistance to stronger challenge.[38]

Meta-analyses in health communication have even established that the stronger the fear appeal, the greater the impact on attitudes, intentions and behaviour change. Furthermore, these analyses indicate that fear appeals are effective in most circumstances and rarely backfire or lead to undesirable outcomes.[39,40] While this may appear to contradict one of our main assumptions—that strong fear appeals related to pollutants will backfire and deter people from consuming crops grown with treated wastewater—this is not the case. In health communication, the usual advice is to avoid consuming contaminated or unhealthy goods. In our context, however, the request is more counter-attitudinal, urging potential consumers to engage with pollutants that they assume are present, which goes against strong basic emotions such as fear and disgust.

Consistent with the principles of cognitive dissonance[41,42] fear-inducing messages might thus not always provoke reactance as expected; instead, in some cases they can justify the anxiety. If the fear triggered in an inoculation message is too intense or aligns with individuals' existing fears, it may not prompt counter-argumentation but rather lead to more evasive strategies. Fear appeals therefore need to be carefully chosen and calibrated to avoid overwhelming people's cognitive and affective defences.[43,44] Research on effective communication strategies for climate change and imminent environmental challenges such as water scarcity and drought indicates that relying on fear-based messaging may indeed be ineffective, as it can suppress individuals' willingness to take action.[45]

Counteracting fear

As already observed, literature on wastewater reuse provides limited guidance on constructing positive counterarguments against perceived threats. Other bodies of research provide more actionable insights, many of which are commonly referenced in environmental communication literature. In the following section, we discuss key aspects of these contributions that have directly informed the design of our research.

The earlier mentioned meta-studies in health communication suggest a strong, even "multiplicative," relationship between perceived threat and perceived efficacy.[40] Perceived efficacy consists of two key components. The first is perceived self-efficacy[46] or the related notion of perceived behavioural control,[47] both of which refer to an individual's belief in their ability to perform an action or behaviour. These constructs are

widely referenced in environmental communication studies.[48] The second component, perceived response efficacy (or outcome expectancy), pertains to an individual's belief that the recommended action will effectively contribute to achieving the desired goal or mitigating a threat. Additionally, group efficacy refers to the belief that the goal can be achieved by collective effort.[40,46] Together, these dimensions shape how individuals respond to threats and recommendations. High levels of perceived self-efficacy and response efficacy increase the likelihood of adopting the pro-environmental behaviour, whereas low perceptions in either dimension may hinder action.[49]

A compelling argument that complements the concept of response efficacy is that outcomes should be framed in concrete terms as tangible outcomes that align with the self-interest of the target audience.[50] Research indicates that individuals who prioritize self-transcendent life goals (*e.g.*, caring for others, protecting the environment) are more likely to value environmental protection over economic growth and to engage in pro-environmental behaviours. In contrast, those who prioritize self-enhancing life goals (*e.g.*, personal success, status and income) tend to hold more egoistic concerns about environmental issues, favour economic growth over environmental protection, and are less likely to engage in pro-environmental behaviors.[51] In the specific context of treated wastewater reuse, studies suggest that messages emphasizing self-interest can shape individuals' emotional responses to wastewater reuse, potentially influencing their acceptance and behavioural intentions.[52]

Adding to this complexity, social learning theory posits that scientific verification is often a last resort for individuals seeking to verify their beliefs and adjust their behaviours. Rather than immediately relying on logical verification or established knowledge to identify fallacies in their thinking, individuals first turn to experiential verification—assessing the adequacy of their thoughts based on the outcomes of their actions or by observing the effects of others' interactions with the environment. When experiential verification is difficult or impractical, people rely on social verification, evaluating the validity of their views by comparing them to the beliefs of their social networks. As Bandura observes, social verification can "foster bizarre views of reality if the shared beliefs of the reference group with which one affiliates are peculiar and the group is isolated from outside social ties and influences".[46] However, research literature on public understanding of science indicates that scientists should acknowledge that lay knowledge is not merely "an impoverished or quantitatively inferior version of expert knowledge" but rather a qualitatively distinct form of understanding that they must learn to understand if they are to be able to communicate effectively.[8,53]

Research design

To explore how people respond to media messages about wastewater reuse, we employed a reception analysis approach. In communication studies, this approach is used to examine how people engage with media content and interpret messages in relation to their sociocultural background, living conditions, social position, values, personal experiences, and other contextual factors. To operationalize this approach, we developed simulations of Dutch-language news articles designed to elicit participants' thoughts, feelings, and associations regarding a field experiment that involved using treated municipal wastewater for groundwater recharge through subirrigation on farmland in northern Belgium (Kinrooi, Flanders).

This format was chosen to enhance external validity, as exposure to news media constitutes a real-world media experience, and news articles serve as a strong representation of the broader news genre.[54] To ensure the articles were realistic, we drew inspiration from typical news values and storytelling techniques[55] and had the articles proofread by a professional newspaper journalist specializing in environmental reporting. Additionally, the news stories referenced an actual pilot project on water reuse for irrigation in Belgium—the country where the survey participants reside—further strengthening the external validity of the cues used in our research.

In developing the content, structure and arguments of the articles, we drew on the theories discussed earlier relating to communication strategies that emphasise fear as a motivator for environmental behaviour, as well as those that focus on fostering a sense of control and willingness as drivers of pro-environmental behaviour.

The first article was structured according to the principles of inoculation theory. Inoculation messages are a form of two-sided communication consisting of two key components. The first, a 'forewarning', alerts individuals to an impending challenge to their beliefs, creating a perception of threat and priming them to recognize potential attacks on their position. The second component, a 'refutation', provides counter-information to strengthen individuals' ability to defend their beliefs against future challenges. The forewarning thus explicitly notifies individuals of an upcoming threat to their desired position, while the refutation equips them with the tools to counter such challenges effectively.

The first article incorporated an explicit negative forewarning explicitly intended to invoke emotions of fear and disgust. This paragraph referred to protests and statements from Australian action groups expressing concerns about contamination, using emotive language such as "sewage" to frame the issue negatively (fear and disgust). This article is referred to as the 'contamination frame condition'.[6]

In the second article, the forewarning from the previous condition was replaced with a paragraph discussing the consequences of recurring droughts. Wastewater reuse was presented as a solution to address water scarcity, rising water costs, and the impacts of drought on daily water usage (outcome efficacy; self-interest). This article is referred to as the 'drought frame condition'.

Both warning paragraphs were followed by an identical refutation text, which consisted of three paragraphs. Each paragraph was informed by the positive argumentation strategies outlined in our literature review. The first paragraph referenced European water quality standards and the successful tests conducted by the research team on over 40 "chemical and

microbiological substances" (scientific verification). The second paragraph highlighted successful international examples (tangible outcomes; experiential verification). The third paragraph emphasized the role of personal and collective actions in achieving desired outcomes (self- and group efficacy).

Since the advocacy text was identical for both conditions, it also functioned as a baseline text, allowing for a comparison of the effects of the two forewarnings. The reception of this refutation was tested separately and is referred to as the 'advocacy condition'.

Finally, a fourth condition was created consisting of three short sentences providing basic information about the topic. This short text is referred to as the 'minimal information condition'. This condition is critical to our research because understanding the reception of media messages about wastewater reuse depends not only on the content of the messages but also on the interaction between this content and pre-existing representations of the topic in people's memory.[56] The three sentences of this condition were also included as the introduction to the three full-text news-type messages presented earlier.

For the interpretation of the response to the minimal information condition it is important to note that, unlike in other countries, wastewater reuse is not a public controversy in Belgium, which minimizes potential political bias and reduces the polarization of opinions that could distort people's thinking about wastewater reuse.[15] At the time of data collection, the use treated municipal wastewater for groundwater recharge and irrigation had received only very limited media attention. In April 2021, there was one local radio clip and one newspaper article, and in September 2022, there was one additional local radio clip about the ongoing experiment. It can thus be reasonably assumed that participants were generally poorly informed and attitudes had not been influenced by prior media coverage.

To analyse the reception of all four articles, we employed resonance analysis. By examining cognitive–emotional interactions, resonance analysis offers insights into how people perceive and interpret information within social contexts, and it reliably predicts behaviours. Previous research has demonstrated that resonance analysis effectively captures patterns in how individuals respond to media messages framed in various ways, aligning with cognitivist and congruency theories.[10] Resonance analysis integrates multiple research instruments, the application of which is described step-by-step in the following paragraphs.

To capture people's spontaneous responses a thought elicitation test is used. Thought elicitation is a method designed to prompt participants to generate spontaneous associations with a topic without external cues.[57] This approach serves two main purposes: first, it reduces bias by eliminating predefined questions or response options, thus minimizing researcher assumptions. Second, it taps into automatic thinking—cognitive processes that occur rapidly and largely without conscious awareness. This type of thinking is typically employed in the context of everyday life and when people consume media messages.[58]

Participants ($n = 360$ per condition) read one of these four articles and subsequently completed a thought elicitation test. Quota sampling was employed to ensure the sample was representative of the Flemish population in terms of age, gender, and educational attainment. Participants were prompted with the open-ended question: "What thoughts come to mind when you think about eating vegetables grown with treated wastewater? write what comes to mind in the boxes below. Your answers can be a single word, a phrase, or a sentence." To maintain the quality of responses and ensure that they reflected participants' spontaneous associations, participants were not informed about the topic of the articles prior to the test and no probing questions were asked.

All verbatim responses were coded *in vivo* using MAXQDA software and subsequently re-coded into broader semantic categories, as shown in Table 1. To ensure reliability, a triple coding procedure was employed. Disagreements among coders were resolved through discussion and consensus. If any of the three coders expressed uncertainty about assigning a concept to a category, the concept was excluded. The frequency distribution of categories typically reveals a tipping point—usually around 10% of respondents—beyond which the number of shared concepts in a category declines rapidly. In this analysis, the tipping point occurred at approximately 8% across the different conditions. As a result, categories mentioned by more than 8% of participants in any condition were included in the analysis.

After grouping respondents' words or phrases into homogeneous semantic categories, Multiple Correspondence Analysis (MCA) was applied to identify frequently co-occurring concepts. MCA is a statistical technique used to analyze relationships between categorical variables by visualizing them in a multidimensional space.[59,60] In this study, MCA allowed us to map how different semantic categories cluster together in a two-dimensional space based on their co-occurrence in participants' responses. This approach helps revealing which concepts are closely associated in people's mental representations and which remain distinct.

Results

This section describes and interprets the data as visualised in the four MCA plots, with one plot corresponding to each experimental condition (for detailed coordinates). Actual water saving behaviour and intended consumption of reused wastewater as well as attitudinal variables related to fear of contamination and trust in science have also been shown to be consistently related to the cognitions represented in these MCA plots. Age, gender and education have been shown to have little or no influence.[10]

Condition 1: minimal information

The MCA plot for the minimal information condition (Fig. 1) presents a two-dimensional representation. The vertical axis corresponds to Dimension 1, accounting for 58.8% of the inertia of the conceptual categories. The horizontal axis

Table 1 Overview, description and frequency of categories

Categories		Mini[a] $n = 360$	Advo[a] $n = 360$	Conta[a] $n = 360$	Drht[a] $n = 360$
Pro-environment	When the idea has expressed that reuse is good for the environment; less damaging, eco-friendly, environment-friendly, less polluting, ecological	64	75	80	76
No problem	When the idea is expressed of not seeing a problem; when the idea is perceived as a logical solution for a (future) problem; trustworthy, and worth a try	53	48	69	54
Sustainability	When reuse is associated with sustainability; it is linked to a circular economy, circular uses and applications, recycling	50	46	16.4	58
Doubts	When questions and critical observations are raised that express scepticism, hesitation, reluctance, caution (because of insufficient information)	44	58	62	45
Water saving	When the idea is expressed that this can be a water-saving measure, but not using more abstract notions such as circularity or sustainability	44	44	57	49
Appreciation	When the idea is expressed that this is a useful and sound idea or plan; with substantial benefits for (future) society and generations	42	46	53	50
Urgency	When the idea is expressed that this innovation is urgent, necessary in view of the future; that there is no escape from, that we have no choice	30	30	30	23
Pollutants	When referring to specific contaminants or residues; when the idea is expressed that the water is not clean or that it is still wastewater/sewage	40	53	47	46
Control	When mentioning the importance of reliable controls; the need for trust in institutions that monitor and certify the water quality; the need for transparent communication	38	46	65	58
Health concerns	When concerns about health risks are expressed, such as diseases, infections, hygiene issues, viruses, contamination, cancer	36	44	39	41
Ecological	When the association is made with ecological (green) thinking and policy, environmentally responsible behaviour (usually by calling it ecological or eco)	34	47	34	34
Equivalence	When treated wastewater is compared to other water and water reuse measures and found to be as good or as bad, and sometimes even better	34	28	24	35
Repulsion	When disgust and repulsion are expressed; by referring to faeces, stench, vomit, rats, and sewer; by dismissing the idea as awkward, dirty, nasty, and unhygienic	34	39	40	30
Science and Innovation	When the association is made with science and technology, scientific research and innovation, novelty, progress; smart, intelligent, and original interventions	26	27	39	51

Table 1 (*Contd.*)

Categories		Mini[a] $n = 360$	Advo[a] $n = 360$	Conta[a] $n = 360$	Drht[a] $n = 360$
NA	When the answer in any one of the 5 answering boxes is 'nothing', 'no idea', 'nothing special', 'don't know' or blank	39	30	23	28
Total number of concepts		989	1078	1106	1084

[a] Mini = minimal information condition; Advo = advocacy condition; Conta = contamination frame condition; Drht = drought frame condition.

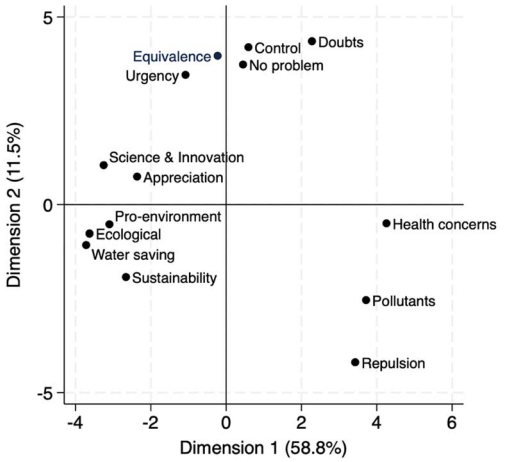

Fig. 1 MCA of the minimal information condition categories ($n = 360$).

represents Dimension 2, which explains 11.5% of the inertia and is considered significant as it exceeds the Kaiser threshold of 7.14 (calculated as 100% divided by 14 concepts). Together, these dimensions account for a cumulative inertia of 70.3%, indicating a robust explanatory result.

The two-dimensional MCA plot is divided into four quadrants. The bottom right quadrant contains three categories: participants who referenced 'pollutants' and expressed 'health concerns' also reported feelings of 'repulsion'. Given the central role of fear in the associations held by this group, this cluster of concepts can be described as a phobic resonance scheme.

The upper right quadrant comprises three categories: participants expressed 'doubts' about the quality of the water or crops. However, they also stated they would have 'no problem' consuming them if adequate 'control' measures were implemented. This conditional acceptance of wastewater reuse suggests that this conceptual system can be termed an ambivalent resonance scheme.

On the left side of the model, the upper left quadrant includes three primary categories. Participants in this quadrant expressed 'appreciation' for the proposed solution, with several describing it as 'innovative'. Two additional categories are positioned at the apex of this quadrant, reflecting participants who emphasized a sense of 'urgency' and argued that the quality of treated wastewater is 'equivalent' to other water used for irrigation. These categories are unified by pragmatism and realism, forming what can be characterized as a pragmatist resonance scheme.

Finally, the bottom left quadrant features a coherent set of categories unified by 'pro-environmental' statements. These include references to the role of water reuse for irrigation in enhancing 'sustainability', mentions of 'water conservation', and the classification of wastewater reuse as 'ecological'. Collectively, these categories depict what can be termed an ecological resonance scheme.

Condition 2: advocacy

As noted earlier, the advocacy article consisted of the full version of the self-constructed news message, excluding any references to fear of contamination or fear of drought. The total inertia of the analysis is 74.1%. However, unlike the two-dimensional MCA plot discussed previously, the current plot is essentially one-dimensional (Fig. 2). Dimension 1 accounts for 68.8% of the inertia between the categorized concepts, which is roughly equivalent to the combined inertia of the two significant dimensions in the minimal information MCA. Dimension 2, with a value of 5.3%, falls below the Kaiser criterion of 7.14%, suggesting that caution should be exercised when interpreting the vertical displacement of variables.

The one-dimensional nature of this MCA plot is a significant finding in itself and warrants further exploration. The previously observed association between the 'doubt' and 'control' categories is no longer present. Instead, the concept of 'doubts' is now closely linked to the negative concepts of 'health concerns', 'pollutants', and 'repulsion'. Conversely, the 'control' category is now associated with positive concepts such as 'innovation', 'ecology', and 'sustainability'. The pragmatist scheme, previously located in the top left of the plot, has thus become more conditional, with respondents initially characterized as pragmatist now displaying greater ambivalence.

On the right side of the model, the distance between 'pollutants', 'health concerns', and 'repulsion' has decreased significantly, indicating a strengthening of the relationships between these concepts. Except for the bottom left quadrant, which still includes the most ecologically motivated respondents, all other quadrants appear to be influenced by the inclusion of the second paragraph of the article, which lists several pollutants and details the chemical tests and

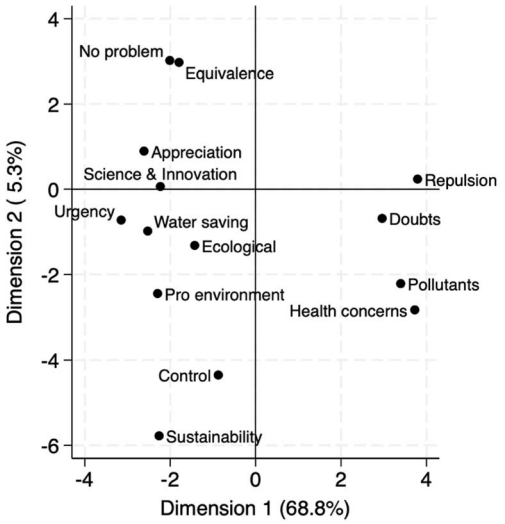

Fig. 2 MCA of the advocacy condition categories (n = 360).

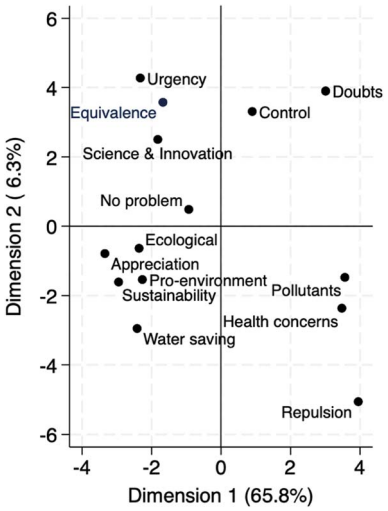

Fig. 4 MCA of the drought frame condition categories (n = 360).

monitoring conducted by scientists. The unexpected discrepancy in resonance between the minimal information condition and the advocacy message likely stems from the inclusion of this paragraph. Although intended to reassure readers, the mention of pollutants appears sufficient to evoke a fear response, a pattern reinforced by the subsequent manipulation in the contamination condition.

Condition 3: contamination

The core text of the news story framed around the fear of contamination (Fig. 3) was identical to that of the advocacy article, but an introductory paragraph was added to strongly imply the risk of contamination and evoke disgust through specific vocabulary. Similar to the advocacy article, the MCA of this message is one-dimensional. The first dimension accounts for 57.6% of the inertia, while the second dimension accounts for 5.6%. The total inertia of this model is 62.2%, which is slightly over 10% lower than the minimal information condtion. Since the second dimension falls below the Kaiser criterion of 7.14%, it should be interpreted with caution.

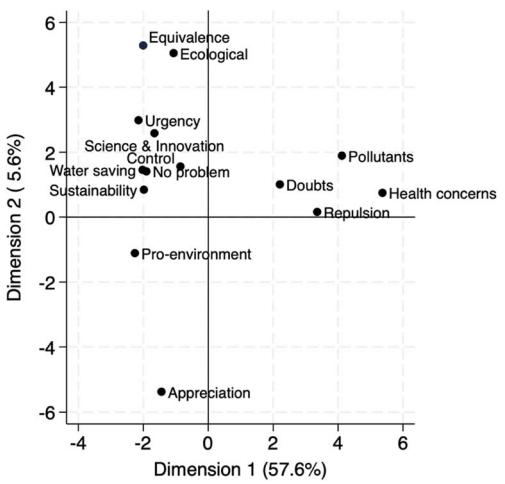

Fig. 3 MCA of the contamination frame condition categories (n = 360).

A discernible pattern emerges when comparing the MCA results of the advocacy article with those of the contamination-framed message. Most notably, the distance between the concepts of 'doubts', 'pollutants', 'repulsion', and 'health concerns' decreases further, indicating stronger associations.

Condition 4: drought frame

The first dimension of this MCA accounts for 65.8% of the inertia between the terms mentioned, while the second dimension accounts for 6.3%. The total inertia of this MCA is therefore 72.1%. Since the second dimension falls just below the Kaiser criterion of 7.14, its explanatory power should be interpreted with caution.

The drought-framed article retains the same text as the advocacy article but begins with a drought warning. Despite minor differences, both articles elicit similar responses (Fig. 4). This MCA plot closely resembles the MCA plot of the minimal information message (Fig. 1). Notably, the relationship between participants expressing 'doubt' and those emphasizing 'control' has been restored. As discussed in the following section, the incorporation of the fear of drought argument as a motivating factor has had a positive influence on the associations of some participants.

Discussion

Given the importance of fear and disgust in perceptions of wastewater reuse, this study was set up as an exploration of the effectiveness of fear appeals in public communication. The literature on this issue remains inconclusive; while some research suggests fear appeals can be counterproductive, overriding moral or rational considerations, other approaches—such as information deficit and inoculation theory—aim to

mitigate fear through increased knowledge or direct engagement.

Both options were considered valid, with outcomes expected to depend on recipients' cognitive and affective predispositions—an expectation confirmed by the results. The findings show a key division among participants: some express uncertainty about the quality of reused wastewater and its potential health risks, hindering acceptance of water reuse schemes for agricultural purposes. In contrast, those confident in science and innovation view wastewater reuse as a viable solution, increasing public support.

The results suggest that trusting participants are more likely to be motivated by broader concerns, such as environmental protection and sustainable water management. In contrast, opponents of water reuse tend to be more risk-averse and primarily focused on personal health. These findings are consistent with the theory of self-enhancement and self-transcendence values developed by Schwartz's value theory,[61,62] which states that people who prioritise self-enhancement values tend to experience higher levels of personal insecurity. This often manifests as concerns about their personal health and safety and reduces a person's mental capacity to engage in pro-social behaviour. People who prioritise self-transcending values, which includes values pertaining to environmentalism and sustainability, have a greater ability to manage their anxiety and focus their attention and efforts on benefiting others.

Finally, an important observation is that the concepts people use to respond to messages on wastewater reuse are not endless, and their combinations follow predictable patterns—what we term 'resonance schemes.' This suggests that while the public is not monolithic, distinct subgroups or target audiences can be identified, allowing for tailored communication strategies.

Recommendations

In the following section, we present evidence-based recommendations for communicating with audiences characterised by high perceived risk. We do this by navigating through the four resonance schemes that were identified in the minimal information condition (Fig. 5) and that reappeared in manipulated form in the three other conditions. This analysis leads to the following practical recommendations.

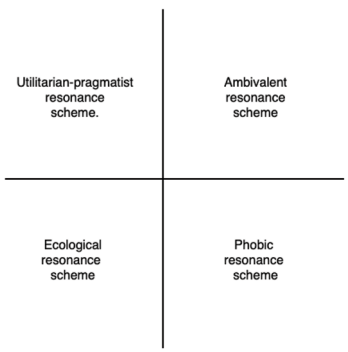

Fig. 5 Summary of resonance schemes.

Phobic target audience

If the target audience is characterised by a phobic resonance scheme, they will tend to prioritise their own health over the environment. They will associate treated wastewater with contamination risks and therefore avoid it. Changing their perspective may be difficult, which makes this audience less important as a target group from an efficiency point of view.

Ambivalent target audience

A more promising target audience is characterized by an ambivalent resonance scheme, considered crucial in environmental psychology and communication as it involves people who are open to pro-environmental behaviour but hesitate for various reasons.[63] Fear of contamination appeares to be a key factor that can quickly discourage them.

The first manipulation, presenting a subsample of participants with the advocacy text, yielded unexpected results: despite being designed to promote positive arguments, it increased fear among negatively inclined participants and induced ambivalence among those previously positively inclined. The most plausible explanation for this effect is the explicit mention of specific pollutants by name in the text, which seems to have increased the fear of contamination.

Based on this finding, a first recommendation is to avoid direct references to pollutants and the naming of specific substances. This includes terms such as 'treated' or 'effluent'; in most cases, 'reused water' or, preferably, simply 'water' will suffice.[33] As this group expresses doubts about wastewater reuse and emphasise the need for quality control and transparent communication, a second recommendation is to offer clear and credible assurances about water quality, but again, as these doubts can easily escalate into fears, careful wording is essential.

Additionally, this target audience shows low levels of trust in science. According to Bandura's theoretical framework,[46] reassurance should therefore be based on experiential verification rather than solely on scientific or logical arguments. As potential consumers may lack direct experience or connections within their social networks, an alternative approach could be to refer to a convincing number of treated wastewater consumers in other countries, preferably with 'cultural proximity' to the target audience so that they can identify with their inhabitants.[64]

Pragmatic target audience

Pragmatic participants tend to appreciate the benefits of water reuse. They trust science and innovation, but nevertheless remain relatively sensitive to fear induction. Pragmatic participants also most clearly identified the utility of wastewater reuse as a bonus. The extent to which these utility considerations are linked to perceptions of individual or societal benefits is difficult to establish. However, framing the promise of tangible outcomes in terms of direct personal benefits effectively appeares to counter their fears.[50,51] This is consistent with meta-theories of self-efficacy and outcome efficacy and supports the value of efficacy-based arguments.[46,47]

Ecological target audience

This target group has the most stable response pattern, which remains consistent across different manipulations. However, instilling ecological awareness is complicated, and we can assume that the ecological argument is likely to be least effective in persuading ambivalent and phobic audiences. As individuals who favour self-enhancing values, they are less receptive to this type of argument and may even react adversely.[65]

Which audience to target?

As discussed earlier, different types of audiences have different sensitivities to different forms of argumentation. For example, anxious audiences may react negatively or even adversely to messages that emphasise environmental values because they tend to be driven by self-interest. In practice, however, communicators may not always be able to target specific audiences, as in the case of the news media. In such cases, it is advisable to focus on the least receptive audiences, following the recommendations outlined above. Those who are already convinced are likely to have their views reinforced by these messages because they are in line with their existing beliefs and values.

Conclusions

Resonance analysis yields data reflecting heuristic thinking, similar to how media messages are typically processed, and is more inductive in nature, helping to minimize researcher bias. However, the research is case-specific and not generalizable. Further testing is required to validate our inferences about the effectiveness of positive arguments. The relationship between threat, positive arguements and outcome efficacy also warrants further investigation.

Nevertheless, our findings suggest that response patterns differ across social groups in response to identical messages. Whether positive or negative arguments are more effective depends on the audience and the relevance of the issue to them. It is also safe to conclude that the persuasive power of environmental messages does not necessarily depend on the positive or negative emotional charge of the messages as such. Instead, it is advisable to look first at the power of the arguments as motivators or disincentives in relation to the concrete issue under consideration.

Ethical statement

This study was exempt from ethical approval by the Ethics Committee for Human Sciences – (ECHW) of the Vrije Universiteit Brussel (VUB), Pleinlaan 2, 1050 Brussel (Advice from the ECHW, Reference Number: ECHW_639), as it did not involve minors, has no harmful or controversial content, bears no risk to participants in completing the survey, contains no deception of participants; did not ask for personal data and relies completely on voluntary participation to the study. The authors confirm that this study was conducted in full accordance with the ethical principles outlined in the Declaration of Helsinki and all data used in this research were obtained and processed in compliance with GDPR.

Informed consent statement

This study utilises survey data collected by iVox/Bilendi from their online panel. Article 7 of the signed agreement between the university and iVox/Bilendi stipulates that both "parties must comply with the relevant laws and regulations applicable to the processing of personal data. This includes Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016, which entered into force on 25 May 2018 (hereinafter the 'General Data Protection Regulation (GDPR)" (**https://www.bilendi.be/assets/images/bilendi-tc-be-nl.pdf**). Furthermore, the participants were informed by the researchers that they would be participating in a study regarding the perception of information provided by newspaper-like articles. In order to avoid any influence on the participants' pre-existing notions regarding wastewater reuse, it was deemed appropriate to refrain from disclosing the topic of the newspaper article beforehand. Participants were informed of this procedure and were able to stop the survey at any time. Participants were given the opportunity to decide whether or not to participate and to ask questions to the researchers. The data were anonymised by iVox/Bilendi prior to delivery.

Data availability

The texts and datasets generated and analysed during this study are available in the Mendeley Data repository: *Resonance of Wastewater* (Verhoest, 2025). DOI: **10.17632/m8sxc52ccr.4**, **https://data.mendeley.com/datasets/m8sxc52ccr/4**. This includes: Datasets (SPSS format) – MCA Coordinate Tables (Stata format) – Back-translated English articles and questionnaires – Original Dutch articles and questionnaires.

Author contributions

All authors reviewed and approved the final version of the manuscript for publication.

Conflicts of interest

The authors declare no conflict of interest.

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