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Citizen science against the plastic soup: background, motivation and expectations of volunteers studying plastic pollution on Dutch riverbanks

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Abstract

In the field of investigating and addressing plastic pollution, the public is increasingly involved in research as citizen scientists. Long-term monitoring for this topic is needed, and recruiting and retaining volunteers is challenging. Therefore, it is important to learn more about the demographic background, motivations and expectations of involved citizen scientists, and if these change during participation. Our research studied these aspects of the citizen scientists in the Dutch Clean Rivers project, who monitor plastic pollution on riverbanks. Participants (n = 122) completed pre- and post-survey after one year of the project. While there was no gender bias, the participants were mostly middle-aged and highly educated, and almost half had previous experience with scientific research. Their motivation to participate was mostly activistic, as they wanted to tackle the source of plastic pollution and contribute to solutions. More personal motivations, such as wanting to learn more and because it is fun to do scientific research, decreased significantly after one year of participation. Their expectations were in line with the main motivations. Understanding the background, motivations and expectations of volunteers helps this project, and the field of citizen science in plastic pollution research.

Keywords plastic pollution; clean-up; citizen science; motivation; volunteer; activistic; citizen scientist

Key messages

- Citizen scientists in the Dutch Clean Rivers project have mostly activistic motivations. They want to tackle the plastic pollution problem and contribute to a solution, rather than wanting to learn about the topic of science or to enjoy time outdoors.
- Expectations for participating in the project are mainly focused on contributing to research and solutions, which is in line with their motivations. Some participants also expect to have fun and meet like-minded people.
- Knowledge about the citizen scientists in plastic pollution projects can help projects recruit, retain and benefit a more diverse group of volunteers, for example, by giving information about possible actions that are being taken and providing opportunities to become more involved in the project.

Introduction

While citizen science, the active involvement of volunteers in scientific research, is already centuries old, it gained popularity over the past 20 years (Bonney et al., 2016; Kobori et al., 2016; Silvertown, 2009). Especially with the development of digital technology and the internet, citizen science has expanded both in the number of projects and across different scientific fields (Bautista-Puig et al., 2019; Pelacho et al., 2020). The goals of citizen science often include: (1) increasing or improving scientific output; (2) allowing volunteers to contribute to science and learn from the experience; and (3) influencing policy. This last goal is particularly relevant for environmental citizen science projects, such as those focusing on plastic pollution (Cigliano et al., 2015; Rambonnet et al., 2019; Zettler et al., 2017).

In the field of plastic pollution research, citizen science has become an important and effective way to reach all three of these goals (Hyder et al., 2015; Rambonnet et al., 2019; Zettler et al., 2017). Approaches involve for example water sampling, or monitoring beaches and riverbanks (Bosker et al., 2017; Rambonnet et al., 2019; Zettler et al., 2017). Most of the publications on the subject of plastic pollution are focused on marine environments; our knowledge about plastic pollution in freshwater ecosystems is lacking (Blettler et al., 2018). In addition, while the involvement of citizen science in this field has been gaining scientific attention in recent years (Cook et al., 2021), it has not been studied extensively.

To monitor plastic pollution effectively, and to study the impact of seasonal or policy changes, repeated measurements over a wide geographical spread are necessary. This results in the need for long-running citizen science projects with large groups of volunteers (Cook et al., 2021). However, for such widespread and long-term projects, it is challenging to recruit enough volunteers, and to keep them involved. It is therefore important to gain knowledge about the background, motivations and expectations of citizen scientists, and how these might change during participation (Eveleigh et al., 2014; Nov et al., 2014; Wright et al., 2015). This knowledge is also important for data quality and quantity, as these can be influenced by the characteristics of the citizen scientists (Gunko et al., 2022; Nelms et al., 2022).

In order to gain more understanding of these aspects of citizen science related to plastic pollution research, we studied the Dutch Clean Rivers project (*Schone Rivieren* in Dutch). In this project, which started in 2017, volunteers monitor the macroplastic litter and plastic pellets on riverbanks twice a year. The project's ultimate goal is plastic-free rivers in the Netherlands by 2030 (Van Emmerik et al., 2020). Our study included pre- and post-surveys focusing on volunteer background and experience, motivations and expectations during the first year of the project.

Volunteer background and experience

The background and previous experience of citizen scientists varies highly between projects, and most likely depends on the topic and type of activity (West and Pateman, 2016). Although our knowledge about the background of citizen scientists in plastic pollution research is limited, there have been numerous

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studies about the demographics of nature volunteers and citizen scientists in other environmental research. Most of the projects using citizen science in environmental research focus on biodiversity monitoring (Pocock et al., 2017). For nature volunteers and biodiversity recorders, an over-representation of middle-aged and highly educated volunteers seems to be a trend (for example, Ganzevoort and Van den Born, 2020). For gender, no clear pattern has been found (Ganzevoort and Van den Born, 2020; Mac Domhnaill et al., 2020). However, qualitative data in one study suggest that beach clean-ups may have an over-representation of women (Nelms et al., 2022).

Understanding the background and previous experiences of volunteers may contribute to improvements of individual projects, for example, through focused communication or the provision of relevant activities (Land-Zandstra et al., 2021). Another issue that makes the study of volunteer backgrounds important is the aim of diversity. A recent study by Nelms et al. (2022) in the UK showed that one of the key themes for clean-up organisations is the need to engage volunteers with diverse backgrounds in terms of gender and age. Involving diverse volunteers in citizen science projects will offer a broader audience the benefits of participation, such as knowledge, skills, enjoyment and social bonding (Phillips et al., 2019; Stedman et al., 2009). In addition, it may also ensure that the goals of projects, such as behaviour change or increased awareness of environmental issues, are spread among a diverse population.

Motivations

Besides knowing who participates in citizen science on plastic pollution, it is also important to know the reasons for their participation (Land-Zandstra et al., 2021). Knowing why people participate in a project will support recruitment and retention of volunteers (West and Pateman, 2016). Several studies have looked into volunteers' motivations in different types of citizen science projects, and have discovered variations among projects. Volunteers often join a project because they have an interest in the topic (Eveleigh et al., 2014; Land-Zandstra et al., 2016a; Raddick et al., 2010). Another often-cited reason is to contribute to science in general (Domroese and Johnson, 2017; Land-Zandstra et al., 2016b; Martin, 2017). Some people join a citizen science project because they want to learn something (Alender, 2016; Martin et al., 2016; Rotman et al., 2012). Other relevant motivations are because the activity is fun, or because volunteers want to engage with people with similar interests (Chu et al., 2012; Lee and Roth, 2003; Rotman et al., 2012).

With such a range of different motivations, it is helpful to define various categories of motivation. West and Pateman (2016) published an overview of studies that aimed to categorise volunteers' motivations to participate in a project, focusing on intrinsic and extrinsic factors. Intrinsic motivations include being interested in, enjoying, or being satisfied by a project, while extrinsic factors include social pressure, rewards, punishment or fear (Nov et al., 2014). Intrinsic motivations may have a larger impact on volunteer engagement and retention (West and Pateman, 2016).

Another framework that is helpful in this sense is that of Rotman et al. (2012), based on Batson et al.'s (2002) four categories of motives for community involvement: egoism, altruism, collectivism and principlism. Egoism reasons are related to the goal of increasing one's own welfare (for example, having fun or an enjoyable experience). Altruism reasons are focused on increasing someone else's welfare (for example, to help a researcher). Collectivism reasons include increasing the welfare of a group (for example, to help cure Alzheimer's disease). Principlism relates to reasons that uphold some moral principle (for example, justice).

Some researchers have suggested that motivations may change over time. According to Rotman et al. (2012), initial motivations for volunteers in ecological citizen science projects were more egoism-related, while altruism and collectivism reasons played a larger role for sustained motivation. Crownston and Fagnot (2008) found that beginners in massive virtual collaborations were often motivated by curiosity, while people who had been in the project for longer periods of time were also motivated by social obligation, shared ideology and satisfaction about their contributions. In contrast, in a study

about a citizen science project about flu symptoms, there were no large differences between beginners and long-term volunteers; for both groups, contribution to science and health were the most important reasons (Land-Zandstra et al., 2016b). It is important to note, however, that differences between beginning and sustained volunteers at one point in time do not necessarily mean that individual motivations change over time. It could also mean that people with a certain motivation are the ones that stay longer, and not that the motivations of longer term volunteers have changed from when they started the project. Therefore, it is important to follow volunteers throughout their involvement in the project via longitudinal studies.

Expectations

Different types of motivations may have different implications for the expectations that volunteers have. For example, they may have expectations in terms of communication with project organisers and scientists, information about outcomes of the project, availability of data and findings, engagement with other volunteers, rewards and recognition (Crowston and Fagnot, 2008; de Vries et al., 2019; Land-Zandstra et al., 2016a, 2016b; Rotman et al., 2012).

There are different ways the public can be involved in science through citizen science. While they can be involved in all phases of the scientific process, in most projects, volunteers either collect data or analyse existing data. Understanding how volunteers want to be involved may also help to keep them motivated (Rotman et al., 2014).

Current study

The aim of the current study was to investigate the background, motivations and expectations of volunteers on the Clean Rivers project. We surveyed volunteers on the project before and after their first cycle of participation (training, monitoring and feedback about the results). The aims of the current study were to: (1) explore the background of the participants; (2) determine their initial motivations; (3) determine their motivations after one full cycle of the projects' activities; and (4) explore the expectations they had about the project and their participation.

Methods

For this study, a mixed-methods approach was chosen, using a survey. We combined closed and open questions in order to get quantitative data for well-researched topics such as motivations and demographics, and qualitative data for topics that were under-researched, such as expectations. To clarify, we call all citizen scientists on the Clean Rivers project 'volunteers'; when we refer to our study participants, we write 'participants'.

Project description: Clean Rivers

In the Clean Rivers project, citizen scientists monitor 100-metre sections along major rivers in the Netherlands, such as the Meuse and the Waal (a branch of the Rhine). The project was developed by the Institute for Nature Education and Sustainability, the Plastic Soup Foundation and the North Sea Foundation. During the monitoring, citizen scientists clean-up and collect data about the amount and types of litter on their 100 metres of riverbank. Volunteers are recruited through social media, local newspapers and digital newsletters. They attend a training workshop before they start monitoring, which teaches them about the project, the organisers, the river pollution problem and the monitoring protocol. This training includes a hands-on fieldwork session to practise the protocol. The monitoring protocol River-OSPAR is based on the OSPAR (Oslo and Paris Conventions) guidelines, so that data from the rivers can be compared internationally with other data sets on plastic pollution (Van Emmerik et al., 2020; Wenneker et al., 2010). After the training, volunteers monitor their assigned track twice a

year, once in spring and once in autumn. They always monitor in pairs, of which at least one member attended the training. After the monitoring period, there is an evaluation meeting; results are shared with the volunteers via this meeting and a report. Furthermore, a larger annual event provides them with workshops, inspiration sessions and networking opportunities. In addition to the citizen scientists, the project also recruits clean-up volunteers, who only collect litter, without monitoring. While the project started in 2017, and is still running in 2023, this study only focuses on the first cycle of participation, and only on the citizen scientists.

Data collection

To study the motivations and experiences of the citizen scientists throughout the project, pre- and post-surveys were designed, in Dutch. Both surveys consisted of a combination of multiple choice questions, five-point Likert scale, and open questions. When registering online for the project and the training workshop, participants received a request to fill in the online survey, explaining that they were not required to do so, and that it would not influence their participation in the project itself. People who had not filled in the online survey were provided with the opportunity to fill in the paper version at the training location before the training started. By filling in the survey, participants gave informed consent for the use of their data. For the consent and processing of the data, ethical guidelines of Leiden University were followed, and the data were processed confidentially; no identifiable information was included in the final database.

This pre-survey contained 31 questions, of which 14 were used for the current study. These questions concerned participants' initial motivations, their expectations, their prior knowledge and experience, and their demographics. Questions regarding motivations were split into two parts. One section was about motivations to join the project in general, so that we could compare them with clean-up volunteers in the same project. The other section was about motivations to participate as a citizen scientist specifically. Both sections were based on existing surveys on motivations of volunteers and citizen scientists (for example, Batson et al., 2002; Land-Zandstra et al., 2016a, 2016b; Raddick et al., 2010). In order to make sure that the statements were relevant and complete, we adapted some of the statements. The survey was pilot-tested with a group of 18 volunteers in a pilot version of the Clean Rivers project.

Participants who had identified on the pre-survey that they were willing to participate in future surveys got an invitation to fill in the online post-survey. This survey was conducted after one cycle of the project (training workshop, monitoring, evaluation meeting and communication of results). On the post-survey there were 42 questions, of which 5 were used for the current study. Those about motivations and preference for information were repeated to measure any changes. In this article, we report on the results of the background, motivations, and expectations of the participants in the Clean Rivers project.

Participants

A total of 221 Clean Rivers participants filled in the pre-survey between September 2017 and January 2018 (75 per cent online, 25 per cent on paper). In comparison, around 230 people attended the training workshops in that period. In June 2018, a personal link was sent to 203 participants who had indicated that they wanted to participate in follow-up research. Between June and October 2018, 163 participants completed the post-survey, representing a response rate of 80 per cent. Of the respondents, 41 were removed from the sample because they did not monitor (for a variety of reasons, such as illness or lack of a monitoring partner) or because they had filled in the pre-survey after the training. This resulted in a sample of 122 participants for this study.

To check whether the 99 dropouts between the pre- and post-surveys were different from the 122 remaining participants, chi-square analyses were performed. We found no significant differences between dropouts and stayers in terms of gender ($\chi^2(1)=0.930$, $p=0.335$) or education level ($\chi^2(4)=8.663$, $p=0.070$). Therefore, we conclude that the current sample is representative of the group of Clean Rivers participants.

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Data analysis

Descriptive analysis was carried out to provide characteristics of the Clean Rivers sample. To determine any significant differences in motivations between the pre- and post-surveys, a paired sample t-test was performed. Chi-square analyses were done to discover any significant correlations between categorical variables. We used Cramer's V to determine effect sizes for the chi-square tests. To determine any groups of similar motivations to participate as a citizen scientist, principal component analysis (PCA) was performed. This analysis included ten variables, and we used varimax rotation. In order to check the assumptions for doing a PCA, the Kaiser–Meyer–Olkin test resulted in a KMO value of 0.814, meaning that the sample was considered good enough for a factor analysis (Hutcheson and Sofroniou, 1999; Kaiser, 1974). In addition, Bartlett's test of sphericity was significant ($\chi 2=508.701$, df=21, $p < 0.001$), showing enough correlation between variables. The analysis resulted in two components with eigenvalues above 1. It was defined as greater than 1, and therefore significant. Together, they explained 79.4 per cent of the variance. To explore the open-ended question about the expectations of the volunteers, a qualitative analysis was done using thematic analysis (Braun and Clarke, 2006). The expectations were manually and inductively coded, and data were analysed in SPSS (Version 27). As the survey was conducted in Dutch, statements and codes were translated into English for the purpose of this article.

Results

Volunteer background and experience

In total, 122 participants completed both the pre- and post-surveys and were involved in active monitoring. As Table 1 shows, the participants were mostly middle-aged, as the average age was 54 years (SD=12.7; range=18-71). Only 7 participants (6 per cent) were younger than 30 years. A little over half of the participants were women (53 per cent). The educational level of the participants was quite high, as 72 per cent had finished higher education. When asked about their employment status, 41 per cent reported that they were either retired or had no paid job.

In terms of previous involvement in scientific research, 45 per cent had had experience with scientific research at school, in their studies or in their profession, but only 7 per cent of the participants had participated in a citizen science project before, for example, a garden bird count. The involvement of the participants in environmental organisations and activities was relatively high. More than three-quarters of the participants already had volunteer experience (78 per cent), while 39 per cent of all participants had experience with environmental volunteering. Also, more than half of the participants (52 per cent) had experience in cleaning up the environment.

Motivations

The motivations statements were divided into two sections: one containing reasons for joining the project in general, and one containing reasons for becoming a citizen scientist.

Motivations for the project in general

Participants indicated their agreement with various motivations to participate in the Clean Rivers project in general (Table 2). Almost all provided statements scored positively (scores above 3). They most strongly agreed with the motivations that they wanted to do something about the plastic soup (*Plastic soup*, 4.75), that litter in nature or on the streets disturbed them (*Disturbing*, 4.74), and that they liked to commit themselves to a better environment (*Environment*, 4.65).

The motivations of the participants in the post-survey revealed a mostly similar picture to the pre-survey regarding the main three motivations (*Disturbing*, 4.82; *Plastic soup*, 4.78; and *Environment*, 4.69). A few statements scored significantly lower in the post-survey than in the pre-survey: because they liked

Table 1. The background of the Clean Rivers citizen scientists who participated in the study (n = 122)

	Frequency	Percentage (%)		Frequency	Percentage (%)
Age (n = 122)			**Science experience (n = 104)**		
≤ 24	4	3	As pupil	10	8
25–34	8	7	As student	21	25
35–44	12	10	As researcher	12	10
45–54	26	21	In citizen science	9	12
55–65	45	37	No experience	67	55
≥65	26	22			
			Volunteer experience (n = 122)		
Gender (n = 122)			Currently	59	48
Female	64	53	In the past	35	29
Male	58	47	Soon	9	7
Other	0	0	Never	19	16
Education (n = 122)			**Member of environmental organisation (n = 122)**		
Secondary school	9	7	Institute for Nature Education and Sustainability	22	18
Vocational training	22	18	Other environmental organisation	56	46
University of Applied Sciences	62	51	No	51	42
			Clean-up experience (n = 122)		
Research university	29	24	Own initiative	38	31
			Neighbourhood clean-up	21	17
Employment status (n = 122)			Riverbank clean-up	19	16
Student	3	3	National clean-up	13	11
Employed full-time	43	35	Coastal clean-up	6	5
Employed part-time	26	21	No experience	58	48
Retired	32	26			
Unemployed	18	15			

to be outdoors (*Outdoors*, 4.22); because they liked to recreate near or on the water (*Recreation*, 3.37); participating as part of work/association responsibilities (*Responsibility*, 2.08); and because they liked to commit themselves to volunteer work (*Volunteering*, 3.66).

Respondents were also asked to pick the most important motivation from the same list of motivations. The most important initial motivation was *Plastic soup* (39 per cent), closely followed by *Disturbing* (33 per cent) (Figure 1).

Motivations for citizen science

In addition to their general motivations for the project as a whole, participants were asked about their motivations to participate specifically as a *river litter researcher*, meaning collecting data in addition to cleaning up litter. The statements were again answered on a five-point Likert scale. Table 3 shows that the most important motivations were: 'with the results, we can tackle the litter at its source' (*Source*, 4.67); 'it's important to gather as much information about litter in the rivers as possible' (*Information*, 4.58); and 'my contribution can help the government/companies take measures' (*Measures*, 4.55). The

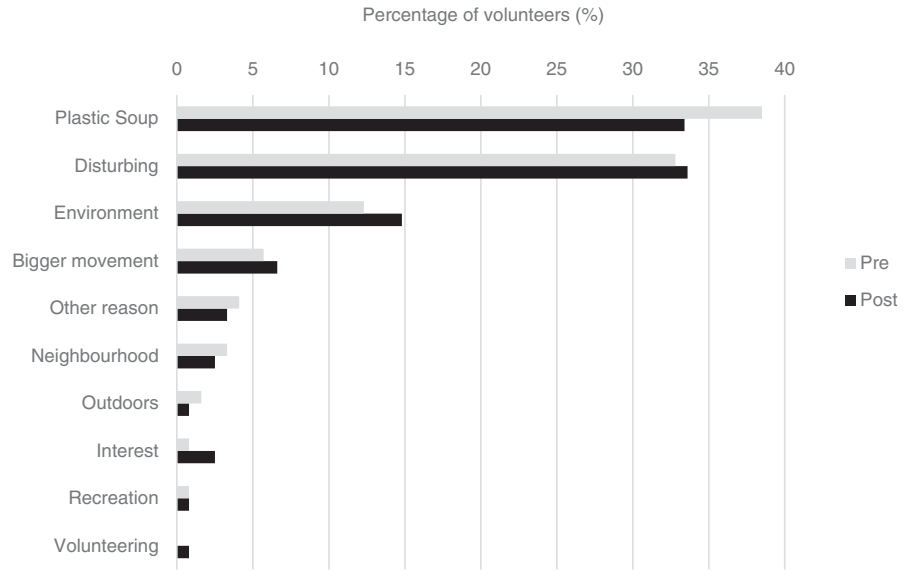
Table 2. Participants' agreement with statements about their motivations to participate in the Clean Rivers project (average on a five-point Likert scale)

I participate in Clean Rivers, because…	Keyword	Pre-survey	Post-survey
I can help doing something about the plastic soup	*Plastic soup*	4.75	4.78
Litter in nature or on the streets disturbs me	*Disturbing*	4.74	4.82
I want to commit myself to a better environment	*Environment*	4.65	4.69
I like to be outdoors	*Outdoors*	4.49	4.22*
I like to join a bigger movement to improve the world	*Bigger movement*	4.16	4.19
I like to commit myself to volunteer work	*Volunteering*	3.86	3.66*
I'm interested in the kinds of litter present in the rivers	*Interest*	3.82	3.66
I like to recreate near or on the water	*Recreation*	3.75	3.37*
I live or used to live close to the Meuse or the Waal	*Neighbourhood*	3.68	3.66
It is part of my tasks/responsibilities for my work/ association	*Responsibility*	2.35	2.08*

Note: Participants' scores before (pre-survey) and after (post-survey) one cycle of participation, scored on a five-point Likert scale, ranging from *totally disagree* (1) to *totally agree* (5) (n = 122).

*Significant differences between pre- and post-surveys: $p<0.05$. For the motivation *Interest* only, the sample size is 121 in the pre-survey.

Figure 1. Most important general motivation for Clean Rivers participants to join the project before their participation and after one cycle of participation (n = 122)



motivations 'to me, it seems fun to perform scientific research' (*Fun*), 'I hope to learn something about performing scientific research' (*Learn*) and 'I'm interested in the performance of scientific research' (*Interest*) decreased significantly in the post-survey. Again, respondents had to indicate their most important motivation (Figure 2). During the pre-survey, their most important motivations to participate specifically as a river litter researcher were *Source* (48 per cent) and *Measures* (27 per cent). In the post-survey, the motivation *Source* (57 per cent) increased, while *Learn* (2.5 per cent) and *Information* (2.5 per cent) decreased.

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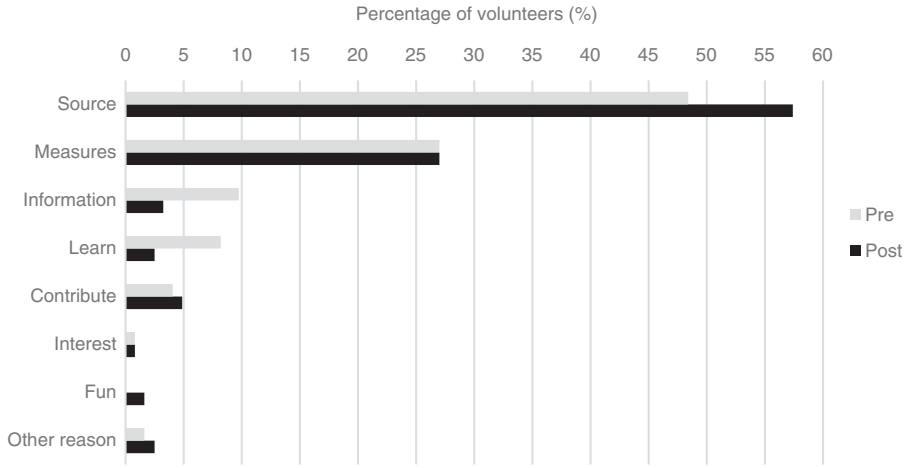
Table 3. Participants' agreement with statements about their motivation to participate specifically as a 'river litter researcher', meaning collecting data in addition to cleaning up (average on a five-point Likert scale)

I want to become/have become a river litter researcher, because…	Keyword	Pre-survey	Post-survey
With the results we can tackle the litter at its source	*Source*	4.67	4.74
It's important to gather as much information about litter in the rivers as possible	*Information*	4.58	4.59
My contribution can help the government/companies take measures	*Measures*	4.55	4.68
To me, it seems fun to perform scientific research	*Fun*	3.96	3.58*
I like to contribute to scientific research	*Contribute*	3.95	3.89
I hope to learn something about performing scientific research	*Learn*	3.94	3.42*
I'm interested in the performance of scientific research	*Interest*	3.87	3.61*

Note: Participants' scores before (pre-project) and after (post-project) one year of participation, scored on a five-point Likert scale, ranging from *totally disagree* (1) to *totally agree* (5) (n = 122).

*Significant differences between pre- and post-surveys: $p<0.05$.

Figure 2. Most important motivation to participate in the Clean Rivers project specifically as a citizen scientist between the pre- and post-surveys (n = 122)



Activistic and personal motivations

To understand whether some citizen science-related motivations correlate with each other, a principal component analysis was performed. In Table 4, the loadings show that there are two groups of citizen science motivations that are strongly correlated with each other. Together, they explain 79.4 per cent of the variation. One group, Component 1, consists of more personal motivations – *Fun*, *Interest*, *Contribute* and *Learn*. The other group, Component 2, involves the more activistic motivations – *Source*, *Measures* and *Information*. When one motivation within a group scores higher, other motivations are scored higher as well. When we look at the most important motivation in the pre-survey, we see that only 16 people have chosen motivations from the 'personal' group of motivations, while the majority (n = 104) have chosen the more activistic motivations. In the post-survey, only 12 people chose a more personal motivation.

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Table 4. The loadings of a PCA for the motivations to participate as a citizen scientist (n = 121), showing the estimated correlations with the estimated components (the two components explain 79.4 per cent of the variation)

	Component 1 (43.8%)	Component 2 (35.6%)
Interest	0.888	
Fun	0.881	
Learn	0.870	
Contribute	0.840	
Source		0.910
Measures		0.901
Information		0.883

Expectations

Participants answered an open question about what their expectations were regarding their participation in the project. Thematic analysis resulted in 16 codes (Table 5). More than half of the participants shared multiple expectations. For example, one participant said: 'hanging out with other nature lovers and enjoy the waterside where we will collect important data. From this, policies can be designed to reduce the enormous pile of litter in nature.' Many participants (n = 40) mentioned that they expected to contribute to something (*Contribute*). For example, participants contribute to 'minimising litter and specifically plastic' and 'scientific research around the litter problems of the river Meuse'. Participants (n = 24) also mentioned research-related expectations (*Research*), such as 'making a meaningful contribution to research and cleaning up litter'. Some expectations (n = 22) were aimed at a cleaner environment (*Clean environment*). For example, one participant expected that 'Clean Rivers will eventually lead to cleaner seas and thereby

Table 5. Overview of codes and code description for participants' expectations about the project

Code	Code description	Frequency
Contribute	Contribute or help with…	40
Research	Studying litter, analysing it, categorising it, mapping it, quantifying data	24
Clean environment	Cleaner or better planet, seas, land, nature or surroundings	22
Knowledge	Improving own knowledge and/or awareness	16
Minimise litter	Either minimising the amount of litter currently present, or preventing litter in general	14
Social	Meeting like-minded people, or inspiring companies or people	13
Feeling	Feels good or powerful	11
Prevention	Prevention, for example, by tackling source	10
Cleaning up	Cleaning up litter	9
Outdoors	Being outdoors	9
Stakeholders	Governmental, companies and consumers	7
Measures	Measures for stakeholders, for example	5
Plastic soup	Plastic soup	3
Awareness	Public/consumer/companies/governments	3
No expectations	No expectations	17
Other		19

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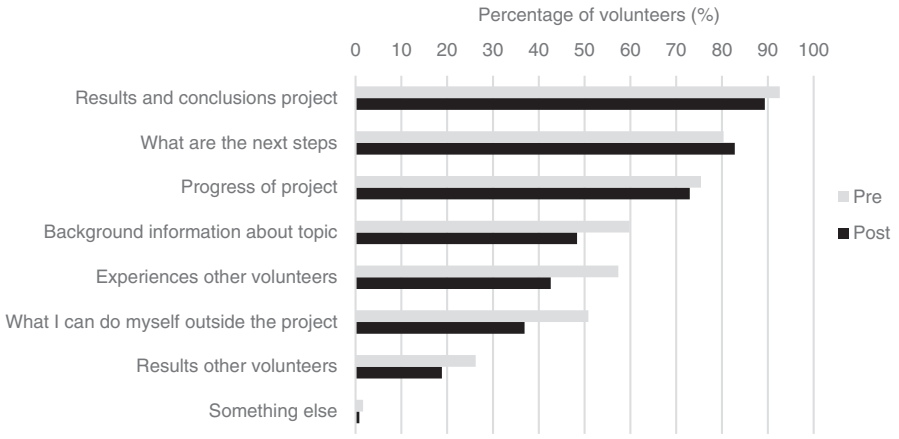
Figure 3. The percentage of participants (n = 122) who are interested in the various types of information, during the pre- and post-surveys



a dramatically healthier planet.' Several participants (n = 17) did not have any expectations, or 'like to be surprised'. More personal motivations were also mentioned (n = 16), such as that they expect to learn something (*Knowledge*). One person mentioned: 'as river litter researcher learning to categorise and quantify litter around rivers. Gain knowledge about the impact of each category on the environment.' Another more personal expectation focused on social aspects during the project (*Social*) (n = 13). For example, a participant said, 'In addition to the results, I would like to gain some new social contacts.'

During the pre-survey, the participants were also asked about their interest in being involved in the analysis of the results, for example, giving feedback on the conclusions or helping to interpret the results. Almost half of the participants (48 per cent) answered that they would like to be involved; 28 per cent said it depends on, for example, 'the complexity' or 'how much time it would take'; and 24 per cent did not want to be involved in the analysis of the results.

During both the pre- and post-surveys, the participants answered a question about their information needs. They said that they were mainly interested in the results and conclusions of the project, in which next steps will be taken, and in the progress of the project (Figure 3). In the post-survey, we saw clear decreases in their interest in the experiences of other participants, as well as in what they can do themselves outside the project and the background information about the topic.

Discussion

As the number of citizen science projects has been rapidly growing, more and more volunteers are becoming involved in scientific research. However, recruiting and retaining volunteers is challenging, and knowledge about the citizen scientists in plastic pollution research is lacking. Therefore, we studied the background, motivations and expectations of volunteers in the Clean Rivers project in the Netherlands. We found that these citizen scientists are middle-aged and well-educated and that, although a large proportion of the participants have had experience of volunteering and clean-up activities, only a few had experience with citizen science. Their motivations were mainly activistic, as they want to tackle the source of the litter and contribute to new measures from the government and industry to solve the problem of plastic pollution. More personal motivations decreased significantly after the first cycle of the project, while the activistic motivations remained the most important. Participants' expectations were in line with their motivations: expecting to contribute to results and knowledge about plastic pollution, and making an impact on solving the plastic pollution problem. Several participants mentioned that they are expecting more personal aspects, such as enjoying being outdoors and meeting new people.

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Volunteer background and experience

The average age of the participants (54 years) and the low representation of young people (below 30 years, 6 per cent) are in line with other citizen science and nature volunteering projects. While there is not a trend in the average age of citizen scientists, an over-representation of middle-aged volunteers is common in citizen science projects and Dutch nature volunteers (Ganzevoort and Van den Born, 2020; National Academies of Science, Engineering and Medicine, 2018). While young people are generally more concerned about environmental problems (Gifford and Nilsson, 2014; Liere and Dunlap, 1980), their numbers in citizen science projects remain low. It is not clear what causes this discrepancy (Herodotou et al., 2020). Specifically for Clean Rivers, a possible factor that might have influenced the recruitment of younger participants is that the monitoring sites are in remote locations.

Regarding the large proportion (72 per cent) of highly educated Clean Rivers participants, studies of the public perception of plastic pollution found that more highly educated people also have a higher level of concern for the environment. This possibly explains their over-representation in the current project (Hartley et al., 2018). Similarly, Ganzevoort and Van den Born (2020) found that 65 per cent of Dutch nature volunteers were highly educated. A high representation of highly educated people is also in line with other studies on citizen scientists (Mac Domhnaill et al., 2020; Raddick et al., 2010). The fact that many citizen science projects attract highly educated volunteers may reproduce the inequalities and under-representation that we see in the science field (National Academies of Sciences, Engineering and Medicine, 2018). Projects should put great effort into attracting a more diverse audience. A targeted recruitment strategy in which volunteers from diverse backgrounds are personally invited could be one strategy to acquire a more diverse group of volunteers. Also, the recruitment message could be adjusted to target a more diverse audience, which has proven to be effective in a study focusing on Dutch citizen science projects (Brouwer and Hessels, 2019).

In contrast to the skewed sample with regard to age and level of education, the gender distribution in the Clean Rivers project was quite equal, and comparable to the Dutch population (53 per cent female, 47 per cent male, 0 per cent other; CBS, 2018). Although there does not seem to be a trend regarding gender in citizen science projects, our sample is more balanced than the study on Dutch nature volunteers, in which 63 per cent were men (Ganzevoort and Van den Born, 2020). Previous studies did find that women are more environmentally aware about the problem of litter and strategies to mitigate the problem (Hartley et al., 2018; Soares et al., 2021).

Although most of the participants of the Clean Rivers project had experience in volunteering, and more than half had experience in clean-up initiatives, only 7 per cent had experience in citizen science. This means that a new audience is being involved in citizen science. Possibly the topic of plastic pollution has drawn them to this project, and has given them an introduction to citizen science.

Motivations

Our results show that the most important motivations of the participants to take part in the Clean Rivers project in general, and as a citizen scientist in particular, had to do with the overarching goal of tackling plastic pollution and improving the environment. These activistic motivations scored higher overall than the more personal motivations, such as enjoyment and learning. This is in line with the recruitment message of the project, which also focused on these activistic goals. It may be that attracting such a volunteer population results in highly motivated volunteers who will stay with the project for a longer time (West and Pateman, 2016). However, the project will also only reach people who are already on board with the goals of the project.

When comparing motivations in the pre- and post-surveys, the more personal motivations, such as being interested in scientific research, wanting to learn, and considering it to be fun to participate in scientific research, declined significantly. This is in line with previous research. For example, Rotman et al. (2014) found that for initial participation, more 'self-directed' motivation is important, such as personal

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interest, but for continued participation, 'commitment for conservation' is more important. However, in the current study, the altruistic motivations already scored high from the beginning. More long-term monitoring of the volunteers' motivations and how they may change can contribute to our understanding of changes in motivations over time. Although each project has its unique characteristics, it would be good to use an overarching framework for motivation, so that different projects can be compared (Levontin et al., 2022).

Participants in our study also acknowledged the importance of collecting as much information as possible. This is a promising outcome, as Nelms et al. (2022) found that one of the challenges for collecting 'scientifically meaningful data' was volunteers' motivation. In their study, volunteers were more interested in cleaning up than in collecting data. Clean Rivers participants seem to be aware of the importance of collecting data, which will presumably improve the data quality.

Expectations

When participants were asked about their expectations for the project, most mentioned that they expected to contribute to results, knowledge, a cleaner environment and reducing plastic pollution. These expectations line up with their predominantly activistic motivations. Although personal motivations were not as important as more activistic motivations, some volunteers did mention that they expected to learn from their participation in the project, to meet like-minded people and to feel good. In addition, they wanted to receive information about results, the next steps and the progress of the project. These results fit the fact that volunteers wanted to make a change. They are also similar to the findings of McAteer et al. (2021), who found that one-quarter of the volunteers in marine community science projects in their sample could be described as activists who wanted to be involved, not only in providing data, but also in disseminating results, raising awareness and really making change happen.

Knowing that volunteers are most interested in the results and outcomes of the project makes communicating the results of the project with them important, showing them how valuable their efforts are (de Vries et al., 2019). Seeing the impact that their work has on science or policies can influence their motivation, and possibly contribute to the retention of volunteers (Eveleigh et al., 2014; Nelms et al., 2017; Zettler et al., 2017).

Limitations and future research

A few limitations of our study should be taken into account. First, the response rate for the pre-survey was quite high, but it declined for the post-survey. Although we checked for differences in demographics between the people who did and the people who did not respond to the post-survey, we cannot be sure that the groups are not different in terms of motivations or expectations. Possibly, people with a more activistic motivation could have been more inclined to stay in the project and to complete the survey. This should be considered for future studies.

In addition, the motivation questions were asked at the start of the survey. Answering these may have had an impact on respondents' answers to other questions, such as about their expectations.

Implications

The key findings from this study are that the Clean Rivers project attracted a highly educated and somewhat older age group, and that most citizen scientists in the project have strong activistic motivations. This has several implications for the project, of which some have already been implemented. First, information that was given to participants during evaluation meetings and symposia was aligned to this motivation. For example, project organisers presented the main conclusions from the data, and the steps that they were taking regarding action towards the main polluters, emphasising the value of the data of the volunteers. Second, during recruitment of new volunteers, the activistic motivation can be taken into account in order to attract highly motivated volunteers. However, the recruitment of new volunteers should also focus on

trying to attract a more diverse group of volunteers by using different media and messages, for example, using a social media campaign to attract a younger audience.

Although the current study investigated only one project, we can draw some implications for the field of citizen science in general. First, we conclude that each project will have a different profile of most important motivations, and that those motivations will correspond to different expectations. Being able to predict or determine those motivations and expectations will help recruit and retain volunteers in the long run. Assumptions about motivations should not be taken for granted. Last, a topic such as plastic pollution may draw a new audience to citizen science. These newcomers may then become aware of the impact that collecting data and performing research can have on tackling environmental problems.

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Declarations and conflicts of interest

Research ethics statement

The authors conducted the research reported in this article in accordance with the Dutch codes of conduct for academic practice and research integrity. No specific ethics approval was needed at the time of this research.

Consent for publication statement

The authors declare that research participants' informed consent to publication of findings – including photos, videos and any personal or identifiable information – was secured prior to publication.

Conflicts of interest statement

The authors declare no conflicts of interest with this work. All efforts to sufficiently anonymise the authors during peer review of this article have been made.

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