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Geological storage of nuclear wastes: Insights following the Fukushima crisis



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HIGHLIGHTS

- Major factors influencing the attitude towards nuclear waste disposal were examined.
- The opinion of the Japanese youth before and after the Fukushima events was compared.
- Unemployment and earthquakes are now at the upper end of the thought of dread.
- The government and scientists are highly distrusted by the Japanese youth.
- People might still accept the repository though the NIMBY phenomenon remains high.

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ABSTRACT

The geological storage of high-level nuclear wastes (HLW) has been in the agenda of Japan for several years. Nevertheless, all the research can become meaningless without understanding the public feelings about the disposal. The events at Fukushima in 2011 altered the perception towards nuclear-waste storage in the country. This work investigates the attitude of young Japanese towards the construction of a repository following the Fukushima crisis, and examines how public perception changed after the event. A survey among 545 university students from different regions of Japan addressed three main variables: dread, trust and acceptance. The results suggest that the economy of the country is still the most concerning issue, but there was a dramatic increase of attention towards everything "nuclear". Radiation leakage and food contamination are major concerns as well. The distrust towards the government deepened after Fukushima, although more than half of the respondents would accept the repository. In a clear phenomenon of NIMBY (not in my back yard), the acceptance drops to less than 20% if the repository is to be installed near the respondents' residency. Financial incentives would increase the acceptability of the siting, although only a substantial compensation might minimise the NIMBY in potential host communities.

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1. Introduction

For several years, the Japanese government has been planning to permanently isolate the high-level radioactive wastes (HLW) produced by commercial power plants in the country. According to Garrick (2002), HLW is defined as the radioactive waste resulting from the reprocessing of spent nuclear fuel from nuclear reactors, or other radioactive materials used for defence purposes. The programme involves the construction of an underground storage facility aimed at starting operations by 2030s. The concept of waste management in Japan follows the approach favoured by most countries, essentially based on HLW immobilisation and

direct disposal in stable geological environments. To present however, no deep repositories have been built to fully test the reliability of the system. In this regard, the feasibility of constructing a waste facility depends not only on technical issues, but also on the public attitude and degree of tolerance towards it. Success in nuclear waste policy requires that policymakers understand such public attitudes and concerns and be capable of responding to them (Kraft, 2000). The growing debate about the potential risks and benefits of the repository has prompted a number of studies that explored the factors influencing the acceptance of the technology in Japan over the years (Hinman et al., 1993; Shimooka, 1993; Mizushima and Hayashi, 1995; Tsunoda, 2002; Tanaka, 2004a, b; Siegrist and Visschers, 2013). Gallardo and Aoki (2012) also investigated the attitude of young Japanese towards the geological storage of radioactive wastes and analysed a set of variables affecting people's perception. Nevertheless, data was

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collected before the “2011 Tohoku Earthquake and Tsunami” which led to the meltdown at the Fukushima nuclear reactor. This particular event brought to surface the worst fears of the society towards nuclear power, and generated a new perception of its risks. The accident at Tepco's power station in Fukushima drew the world's attention for several weeks and highlighted the catastrophic effects of a radiation escape. For nuclear opponents, Fukushima was a clear example of the close relationship between “nuclear” and “disaster”. Moreover, the confusion and contradictory information released during the days of the crisis undermined the credibility of Japanese authorities and prompted worldwide criticism about the management of the situation. Public anxiety about the reactors safety rapidly spread out beyond Japan, leading to some countries, such as Germany, Italy, Switzerland and Venezuela, to review their policies on nuclear power. Fear intensified also in neighbour China despite repeated governmental announcements that the country faced no imminent health threats from Fukushima (He et al., 2013). March 2011 suddenly modified the world scenario, so all in all, it is hypothesised that trust in regulators and the public perception on geological disposal (and anything “nuclear” indeed) changed significantly after the crisis. Nowadays, the debate about nuclear power and its residues continues, and the construction of a geological repository is likely to follow a thorny road to the least. As an example, in March 11th 2013 about 40 Greenpeace activists managed to break into the reactor of a nuclear power station in the Cordoba province of Argentina to protest against the use of that technology (La voz del interior, 2013). In this context, the present paper investigates the attitude of young Japanese towards the siting of a nuclear repository following the Fukushima accident in 2011, and examines how public perception changed in relation to this event. A survey was conducted in Japan in late 2012–early 2013 and its results compared with findings prior to the earthquake as published by Gallardo and Aoki (2012). In line with the precedent study, the analysis focused on a handful of variables such as fear, trust in authorities, and acceptance of the facility. Furthermore, the paper examined how important nuclear issues are for the Japanese public in relation to other concerns, and explored the role of NIMBY (not in my back yard) on the HLW repository. Some general strategies to facilitate the repository siting were also explored. The paper is organised in four main parts: (1) Introduction, (2) Methods, (3) Results and Discussion, and (4) Concluding remarks. A number of subsections have also been introduced for clarity purposes and to better discriminate between key concepts. To present, the authors are not aware of other studies examining in a systematic way the change in public attitude towards HLW storage in Japan following the Fukushima event. The formulation of energy-production and disposal policies is intrinsically shaped by people's perception which in turn, cannot be analysed in historical isolation. The present study assists in gaining a better understanding about current public views on nuclear waste disposal and its evolution in time, and is expected to provide a valuable reference for policy makers and scientists assessing the viability of geological storage in Japan.

1.1. Background of geological disposal in Japan

Until the Fukushima crisis in 2011, more than 50 nuclear power stations scattered throughout the country constituted the core for electricity generation in Japan. Research and development for geological disposal in Japan was initiated in 1976 as a key national project (JNC, 2000). The establishment of an organisation to implement the storage as well as demonstrations of repository technology commenced after the year 2000. According to the road map of the Atomic Energy Commission of Japan (AEC), the vitrified HLW should be stored underground by 2030. From a technical

point of view, there is ample consensus throughout the world that geological storage is currently the most favourable option to deal with HLW. Existing scientific research still confirms that in view of the available technologies and the pressing need to dispose the wastes in only a few years, a deep underground facility is the most acceptable solution.

The geology of Japan is complex and largely affected by tectonic and volcanic activity. Therefore, the Japanese disposal concept places greater emphasise in radionuclide containment by engineered barriers rather than geological immobilisation. In this regard, the disposal implies the construction of a deep facility with a variety of concrete and bentonite barriers able to isolate the migration of radionuclides far beyond the foreseeable future. One of the first steps to ensure the long term safety of such a disposal is the selection of a stable geological environment. This led to the construction of the underground research laboratories of Mizunami and Horonobe, to verify in-situ the reliability of nuclear waste disposal in crystalline rocks and sedimentary deposits respectively. In spite of the major advances achieved and the vast number of publications so far released (eg. Kimura and Muraoka, 1983; Koide et al., 1991; Kimura et al., 1995; Umeki et al., 2003; Sugita et al., 2007; Ohi et al., 2013; etc.), the authors argue that the majority of the Japanese people are not aware of the existence of HLW and its management. In dialogue with stakeholders (i.e. university students, colleagues from other disciplines in the scientific community, and residents of varied background and age in areas where our projects are undertaken) we found not only low levels of awareness but much scepticism if not fear, when realizing that the underground disposal will take place in a country prone to earthquakes and volcanism. Thus, all the technical work carried out over the years can become useless if it is not accompanied with measures to build confidence and achieve reasonable levels of credibility by the public. Regardless of the technical outcome, the destiny of the geological disposal programme is ultimately dependant on the position that the society takes towards it. An analysis of the attitude of the general public is considered crucial to assist policy makers in defining new lines of action that complement all the work that is being carried out by the authors and colleagues on HLW underground disposal in Japan. Findings from the present work are expected to contribute with the programme in moving forward and not end up being a mere theoretical exercise.

1.2. Previous research

The disposal of nuclear waste is generally perceived as a hazard and as such, it leads to public concern and resistance. Previous research by Gallardo and Aoki (2012) upon a population of about 170 university students of various disciplines showed limited awareness of the Japanese youth in relation to the siting of a nuclear waste facility in the country. The students expressed deep concerns about the leakage of radionuclides although their anxiety was overridden by issues with a more direct impact on daily life such as the economy, the health and pension system, and taxes. At that time, nuclear-power generation and the geological disposal of nuclear wastes were ranked almost at the bottom of the list within a series of items that could worry the Japanese society. The study indicated also certain distrust in the authorities and the scientific community. The Parliament was the most distrusted party, as respondents thought that any bill being approved by it would be in favour of the government agenda rather than people's welfare. On the other hand, more than 80% of the students considered that conclusions presented by the scientists working in the programme could be biased. Despite all this negative perception, about half of the interviewed individuals stated that they would still accept the construction of a HLW repository in the country. Furthermore,

opponents to the project appeared reluctant to get deeply involved in the debate suggesting thus, a considerable potential to successfully proceed with the geological disposal. However, the crisis at the Fukushima reactors in March 2011 generated a dramatic change in the perception towards nuclear energy which in turn, would have crucially influenced public's opinions and acceptance of a repository. The new socio-political scenario requires thus an updated investigation about public's attitude towards the geological disposal of radioactive wastes in Japan.

2. Methods

2.1. Procedure

When assessing a risk, the majority of citizens rely on intuitive judgements, the so-called risk perception (Slovic, 1987). More recently, it was proposed that behaviour stems from emotional reactions about hazards in addition to cognitive beliefs (Loewenstein et al., 2001; Slovic et al., 2005). In the case of HLW, recent trends on public attitude would have been shaped by the personal experience following the tsunami and nuclear accident. In effect, people directly impacted by the catastrophe (eg. losing relatives/friends, job, home, etc.) are expected to react in a different way to those unaffected or whose exposure was mainly limited to information received from the media. The psychological effects of the Fukushima event would recede over time leading towards a more objective judgement of nuclear facilities. This context raises the question about the most adequate timing to investigate new developments in social attitude towards a nuclear repository. Looking for a public response too soon may reflect a negative perception as people are still sensitive to the scenario of death and disaster that followed the event. By contrast, collection of data too long after the catastrophe might contain gaps in the factors behind people's attitude. Risk perception is an evolving process, shaped by psychological dynamics and cultural cognition (Kahan et al., 2009) and as such, any observation will be a snapshot of a particular moment in time. Nevertheless, it is necessary to draw a line between the period where people would react in a predominantly emotional manner, and a more mature stage where opinions become somewhat rational and objective. Surveys for the present research were initiated about a year and a half after the Tohoku tsunami, a period expected to be reasonable enough for the community to be less emotional in its responses. The accident at Fukushima shocked the Japanese public and generated an anti-nuclear wave that rapidly spread throughout the country. Following the early months of the aftermath, this trend might have shifted towards a more pragmatic debate about the use of nuclear energy and the production of residues. In effect, the crippled power system was compensated by severe restrictions in electricity consumption such as lightning blackouts, cuts in the use of heating/cooling systems, reduced trains frequency and more importantly, the impact on industrial production with the consequent loss of jobs. Along with energy conservation measures, the government boosted fuel imports adding more pressure to taxpayers while increasing the country's dependence on foreign

markets. Thus, the Japanese public faces the dilemma of accepting the renaissance of nuclear energy or rapidly find other solutions for the sustainable generation of electricity. Till then, the nation risks to live with an electricity shortage, which would directly impact on the economy and wellbeing of the population.

2.2. Questionnaire

A survey instrument addressing 54 items questions was designed to answer the research questions (Appendix A). To simplify comparisons, the survey replicated the questionnaire distributed among university students by Gallardo and Aoki (2012) prior to the 2011 tsunami. The current survey was responded by 545 undergraduate students gathering from most parts of Japan in a series of university lectures on nuclear waste disposal in Saitama, Japan. Saitama locates in the outskirts of Tokyo and as such, is a large metropolis attracting people from all over the country. The participants were regular students enrolled in varied disciplines, with an age range of 18–21 years. University students have already been used as participants in studies concerning risk and social perception (Tanaka, 2004a; Halder et al., 2010), and the usefulness and generality of the approach demonstrated by Maeda and Miyahara (2003). Furthermore, the representativeness of using a students' sample in opinion polls was confirmed by Siegrist (2000), in a study that demonstrated the similarities between causal models created from a dataset obtained from students and from a random sampling. In agreement with Tanaka (2004b), it is also argued that people's attitude in Japan is relatively homogeneous as almost the entire population shares the same nationality and cultural background. Moreover, Japanese people access similar mass media contents and travel frequently between districts. For the present study, the questionnaire was effectively responded by all individuals giving more confidence about its representativeness.

The first item investigated the demographics of the sample, the background on HLW and the knowledge about geological disposal. Next, a set of hazards and social attributes were presented to establish what preoccupies the population most. The third set of variables explored the feeling of dread towards geological disposal. Questions were to be answered on a 4-points scale, from "not worried" to "very worried" excluding the possibility of "I don't know" responses. Trust in authorities and control measures were also analysed on a 4-points scale ranging from "do not believe" to "strongly believe". Finally, the same approach was employed to examine the degree of acceptability towards the nuclear repository, both at the national and local level.

3. Results and discussion

3.1. Respondents' background and previous knowledge

The first part of the questionnaire inquired respondents about their gender and geographical origin, followed by their previous knowledge about HLW and a geological repository. As seen in Table 1, males comprised about 2/3 of the students, with

Table 1
Demographics and respondents' knowledge background.

	Ratio	Knew it (%)	Heard about it (%)	No knowledge (%)	No answer (%)
Male/Female	2.4				
Respondents from Tokyo/Saitama (%)	50				
Knowledge about HLW		37	42	18	3
Knowledge about geological disposal		38	21	34	7

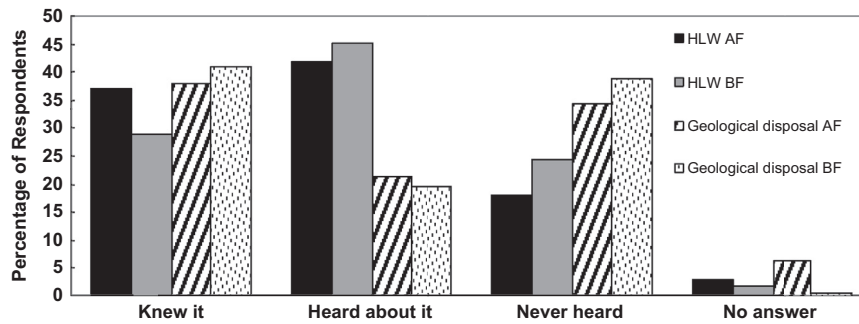


Fig. 1. Public knowledge about HLW before and after the Fukushima crisis.

Table 2
Ranking and shifts in the perception of social issues in Japan.

Item	Before Fukushima			After Fukushima			t-Test analysis		
	Sample no.	Mean	SD	Sample no.	Mean	SD	d.f	t-Value	p-Value
Economy	169	3.6	2.4	546	3.5	2.4	713	0.2	
Nuclear power	168	6.7	2.3	546	3.7	2.7	712	14.1	***
HLW	168	6.4	2.3	546	3.8	2.6	712	12.5	***
Environmental pollution	169	4.2	2.5	546	5.2	2.4	713	-4.9	***
Taxes	168	4.6	2.6	546	5.5	2.3	712	-4.1	***
International relationships	169	5.6	2.3	546	5.9	2.4	713	-1.3	
Crime	168	5.4	2.7	546	6.4	2.6	712	-4.4	***
Education	168	5.0	2.7	546	6.4	2.6	712	-6.0	***
Health & Pension system	169	4.5	2.6	546	6.6	2.5	713	-9.7	***
Immigration	169	9.2	1.6	546	8.2	2.5	713	4.8	***

respondents coming from 37 prefectures around the country. Participants from different regions of Japan, including Okinawa and Hokkaido, provide more confidence on the representativeness of the sample and the generality of the results.

Compared with data collected before the Tohoku tsunami, the number of students knowing about HLW and geological storage increased from 21 to 38% (Fig. 1).

A priori, it would have been thought that media attention and the political debate on nuclear energy installed in the Japanese society from 2011 were the basis for this raise in awareness. Yet, up to 34% of the students had never heard of underground disposal. No correlation appears to exist between awareness and geographical origin either. For instance, research on waste disposal has been taking place for several years in Mizunami and Horonobe, central and northern Japan respectively. Even though these projects are of public domain, several students from those regions had no knowledge at all about spent nuclear fuel and the disposal concept. In previous studies, we suggested the indifference of the Japanese society towards public affairs as the responsible for the low levels of awareness. The past decades have seen a rapid and widely noted increase in the Japanese's electorate's political apathy at the national level (Foljanty-Jost and Schmidt, 2006). This disengagement could still be a key factor to explain why geological disposal is not well known in Japan. However, the Fukushima crisis might have triggered a change in the trend, as seen by the number of protests that took place since the aftermath of the nuclear meltdown. This shift might be the reflection of wider changes in the socio-economic structure of the country over the last years. In effect, the dissatisfaction generated by a stagnant economy, more precarious job conditions, wealth disparity, recent corruption scandals, and the uncertainty about the future could all be contributing to the start of a new era in the Japanese culture.

The increase in the ratio of students that never heard about the technology despite the current context where nuclear energy draws so much attention suggests that some additional factors might be playing a significant role as well. Poor communication

could be one of those reasons. As in civil affairs, technology development is still concentrated in a minority group, in this case research agencies and universities. Findings from the research programs would mainly stay within the scientific community with limited dissemination towards the general public. Alongside with academic divulgation, there is a need to raise awareness and educate the average citizen about energy technologies and disposal strategies. This turns to be especially relevant to overcome the distrust and suspicion raised by controversial developments such as a siting facility. People worry about less understood activities than about those that are well perceived (Sandman, 1987). Thus, it is crucial to communicate with society as a whole to enhance understanding and acceptance of the proposed developments.

3.2. Major concerns of the Japanese youth

It is expected that the Fukushima crisis led to new priorities in terms of concerns for the Japanese youth. Potential differences in opinion before and after the 2011 event were investigated using the Student's *t*-test at the 95% confidence level. Consistently with previous findings, the country's economy remains at the top of the list of the social concerns (Table 2). The number of asterisks indicate the relative level of the *p*-value. In this paper, "***" means $p < 0.05$, "**" means $p < 0.01$, and "*" means $p < 0.001$.

Even when the consumer confidence at the time of the research (the degree of optimism that consumers feel about the overall state of the economy) hovered around historical levels, the uncertainty in the global economy, the persistently limited GDP growth and a more recent decline in foreign sales are all factors shaping the gloomy outlook of respondents. On the other hand, the perception towards nuclear energy shifted dramatically after the Tohoku events, ranking now among the most concerning components faced by the youth. The difference between the level of concern in relation to nuclear power and associated wastes is the largest observed difference among all the analysed factors (mean difference > 2.6). Images of the Fukushima meltdown and

the scars of the accident are still vivid, while the debate about future energy policies is on the rise. Within this context, there is a general fear of “nuclear” or “radiation” regardless whether it is a reactor or a waste facility. However, current views on nuclear energy have not been unknown to other nations in the past. For instance, the 1979 Three Mile Island accident and the 1986 Chernobyl catastrophe brought the first wave of nuclear power to an abrupt end, and social acceptance to very low levels (Liao et al., 2010). Furthermore, over 80% of respondents in the UK opposed to nuclear energy immediately after Chernobyl, compared with 68% in the previous year (Van der Pligt, 1992). Considering the heavy reliance of Japan on nuclear power, and the difficulties of shifting towards other forms of energy without further crippling the economy, the question is how to move forward. Bickerstaff et al. (2008) showed that fears about climate change have persuaded many people who were previously anti-nuclear to reluctantly accept the need for the technology in the UK. Similarly, a number of researchers and public officers conceded that the strong opposition to nuclear power in Japan is expected to ease with time, allowing for a renaissance of the

industry. This idea is backed by the increasing price of fuel fossils, potential new taxes to reduce carbon emissions, threats to Japan energy supply security, and more importantly, reduced power generation. Less energy, either due to closure of nuclear reactors or during replacement by other sources of energy, will have a direct impact on the industrial sector and therefore in the quality of life of the population. In effect, less energy means less production and jobs creation, electricity savings and blackouts, public transport disruptions, and overall, a general change in habits and behaviour that would not be tolerated in the long-term. This reasoning appears to be supported by some developments: Japan shutdown the last of the 50 reactors on May 5, 2012 for the scheduled stress tests and additional safety checks, rendering its electric grid nuclear free after more than four decades (Srinivasan and Rethinaraj, 2013). Since then, the mayors of a number of towns where nuclear plants are located approved restarting the reactors provided they successfully pass the safety checks (McCurry, 2012). This is largely due to the impact of power shortages on local economies and the fear that an increased dependence on fossil fuels will increase electricity tariffs.

3.3. Changes in the feeling of dread

There is a good correlation in the perception of risk before and after Fukushima. Score values show that in general, the feeling of dread remains high (Fig. 2). Possible contamination of the ecosystem has been appraised by most of the respondents as the main dreadful factor for the installation of a storage facility. However, the impact on the environment is not restricted to direct leakage of radionuclides into land or water, but to poisoning of food products. The seriousness of the concern was evidenced by government restrictions on the distribution of food products from the Fukushima region soon after the 2011 crisis. In addition, other measures included prohibition of agricultural activities in designated areas, regular food-quality monitoring, and into a more informal level, the widespread appearance of signs at supermarkets and shops reassuring customers that all products being sold were free of radioactivity. The relationship between the degree of concern against the respondents' prefecture of residence was also analysed (Fig. 3). Overall, students agreed on the fact that radiation escapes with the consequent soil and water contamination are the most concerning issues in relation with the disposal of nuclear wastes. Regardless of their prefecture of origin or place of residence, about 80–85% of the respondents expressed deep concerns over this point. Interestingly, students from the agricultural prefectures of Shikoku expressed the greatest concern about the contamination of food supplies. In contrast, respondents felt at more ease when asked about their fear to sabotage or the decline in property values around the facility. These variables normally scored between 2 and 3 (moderate fear) throughout the country. One of the reasons for this uniformity might be due to the fact that

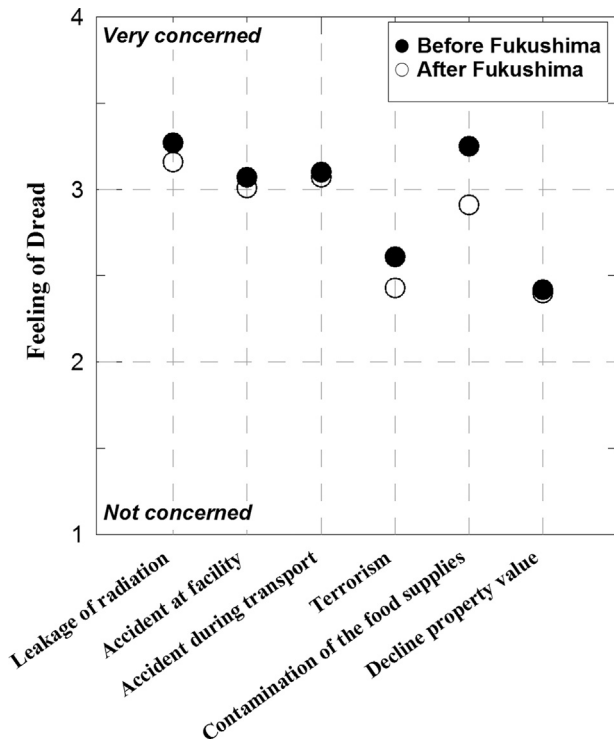


Fig. 2. Change in feeling of dread related to HLW storage.

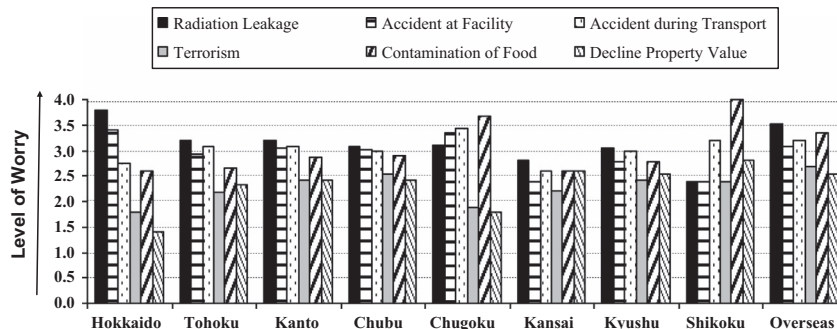


Fig. 3. Fear to HLW storage throughout Japan.

Table 3
What worries the Japanese youth. Before and after Fukushima.

Item	Before Fukushima			After Fukushima			t-Test		
	Sample	Mean	SD	Sample	Mean	SD	Degree of freedom	t-Value	p-Value
Crime	157	3.47	0.66	546	3.17	0.77	701	4.47	***
Terrorism	170	3.42	0.75	546	3.24	0.86	714	2.42	*
Traffic accident	168	3.3	0.73	545	3.1	0.81	711	2.82	**
Economy collapse	170	3.26	0.77	546	3.37	0.71	714	-1.77	
Unemployment	170	3.36	0.82	546	3.53	0.76	714	-2.33	*
HLW	170	3.02	0.81	544	3.33	0.79	712	-4.38	***
Nuclear power	170	2.95	0.85	546	3.29	0.82	714	-4.69	***
Nuclear war	170	3.52	0.82	546	3.4	0.88	714	1.75	
Cancer	169	3.36	0.81	546	3.19	0.89	713	2.16	*
AIDS	170	3.15	0.87	544	3.04	0.93	712	1.36	
Global warming	170	3.34	0.79	545	2.99	0.89	713	4.66	***
Ozone depletion	170	3.28	0.82	546	3.03	0.85	714	3.42	**
Environmental pollution	170	3.38	0.71	545	3.09	0.79	713	4.25	***
Earthquakes	170	3.39	0.82	546	3.42	0.79	714	-0.49	
Floods	170	2.8	0.96	546	3.04	0.93	714	-2.88	**
Tsunami	170	2.68	1.01	546	3.34	0.89	714	-7.61	***

no disposal site has been selected yet. Unlike food contamination, which was fully experienced following the 2011 tsunami, the site selection is something abstract not affecting anyone in particular at the moment. More likely, this trend will change dramatically once a specific location for geological storage is defined. Under these circumstances, it is expected that people living in the peripheries of the designated facility will express higher degrees of concerns that those living away from it, or in other parts of the country.

According to Damasio (1994), thoughts are largely made from images. A lifetime of learning leads these images to be marked by positive or negative feelings and therefore, rationality is not only a product of the analytical mind, but of the experiential mind as well. Our previous investigation revealed that nuclear war was the most feared hazard for the Japanese youth. In line with Damasio's ideas, we believe that memories from Hiroshima and Nagasaki, repeated threats from North Korea, and the recent skirmishes with China in the Pacific Ocean are likely to have influenced the youth perception about nuclear war. Despite a nuclear confrontation remains one of the most feared risks, more compelling issues such as unemployment and earthquakes are now at the upper end of the thought of dread. These results are not surprising considering the difficulties of younger generations to land their first job, and a gradual shift from the lifetime employment culture into a more competitive and unstable labour market. Even though job mobility in Japan remains considerably lower than other countries, no more than 20% of the workers are likely to be employed under informal lifetime employment contracts (Ono, 2010).

As expected, the most dramatic changes in people's attitude after the Tohoku event are related to both tsunami and nuclear energy (Table 3). Concerns about a potential tsunami were at the bottom of the list during the surveys conducted before 2011, but ranked third in the present poll. Whilst such a level of fear might decrease over time, the psychological impact on society appears to be enormous. Nuclear energy and radioactive waste disposal followed the same pattern. The Fukushima crisis made the Japanese society realise that they have a much more limited control over these risks, leading to a sense of vulnerability. As Hinman et al. (1993) suggested, it is not nuclear power itself but rather its potential malfunctions that give rise to fear. The success of any programme for HLW storage relies on people's low levels of fear, which constitute one of the pillars for acceptance. The new survey results clearly suggest a more challenging environment for the acceptability of hazards, factor that should be captured by government agencies when pursuing the disposal strategy.

3.4. Trust in authorities and acceptability levels

Trust in government and associated agencies are a key condition for the acceptance of a waste facility. Our previous work revealed that confidence in the selection and management of the repository were shadowed by distrust in the government, especially at the national level. The new poll suggests that distrust towards the prime minister and the Congress has deepened (Table 4). In effect, there are serious doubts about national authorities, who are blamed for the poor handling of the Fukushima crisis and the reconstruction process. Public anger was also sparked by the idea that the government hides information and played down the nuclear crisis. Thus, one of the problems revealed by the Great East Japan Earthquake was the manipulation of information by withholding and distortion, with the direct impact on public relations (Yamamura et al., 2013). On the contrary, prefecture and municipal governments show more credibility, as they are seen to be closer to the people's interests. Several prefectures and local communities have already expressed their opposition to geological storage enhancing the move against the central authority, which is seen as an intruder (Gallardo and Aoki, 2012). In addition, a number of anti-nuclear rallies in Tokyo and surroundings, the remaining of devastation across the northeast coast region, and the post-disaster challenges faced by many residents have all eroded any confidence in the central government.

Findings from Dalton (2013) show that Japanese people has a marked aversion to protest activities or political confrontation. Yet, there could be signs that this is changing. Protests against nuclear power have been regularly held in front of the Prime Minister's office since March 2012, and most of the participants are just ordinary people (Asada, 2012). The widespread use of social media and internet created a new dynamic in the organisation of protests as well as in the dissemination of information, both in favour and against nuclear energy. This suggests that the inertia that dominated the Japanese society for years might be coming to an end.

Lack of trust in regulatory institutions may prompt people to deem an activity or technology unacceptable (Bronfman et al., 2009). Interestingly however, 26% of the respondents still declared to accept a nuclear waste repository in Japan, while an additional 42% would eventually agree with its construction (Fig. 4). These results suggest that the Fukushima crisis did not alter significantly people's view about a siting facility. It can be argued that the distrust of regulatory agencies could exercise an important influence on public perception, but not to the point of making people reject a technology that is considered necessary for the general

Table 4
Trust in authorities.

Fukushima crisis ^a	Strongly trust		Trust		Distrust		Strongly distrust		Total per cent
	Before	After	Before	After	Before	After	Before	After	
Prime Minister	9.5	3.5	31.4	16.3	36.1	37.2	23.1	42.9	100
National Congress	2.9	3.3	22.9	17.6	47.1	39.3	27.1	39.8	100
Prefecture Gov.	5.9	8.8	34.9	36.3	43.8	35.6	15.4	19.3	100
City Gov.	7.7	10.8	34.9	37.1	41.4	34.1	16	18	100

^a Values representing percentage of responses.

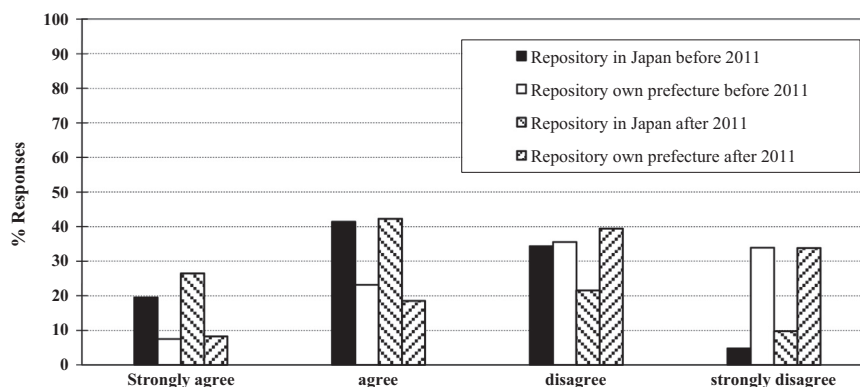


Fig. 4. Level of acceptance to a nuclear repository in Japan.

welfare. Looked in isolation the present results are somewhat misleading, as the high level of acceptance for a waste repository refers only to “somewhere” in Japan. When confronted with the possibility of installing a HLW disposal facility in the surroundings of the respondents' place of residence, the acceptability levels drop to less than 19%, value similar to the acceptance level before 2011. This phenomenon, known as NIMBY (not in my back yard) plays a critical role, as when the time comes, few would accept the siting of the repository. Fear and distrust are expected to be key elements for the high levels of opposition of a local disposal facility. Furthermore, scientific advancements have enabled analysts to detect ever smaller doses of toxins associated with environmental exposures, increasing people's sensitivity to risk (Kikuchi and Gerardo, 2009). There might be some political implications as well. In effect, it is up to the central government to decide where to store the spent nuclear fuel and as such, it is seen both as interfering in local affairs as well as pursuing its own agenda regardless of the community requirements. As noted by Rabe (1994), when regional or central governments have used their authority to pressure local communities to accept the construction of a HLW facility, they faced violent opposition in the majority of cases. Consultative activities are becoming more common place within society, with risk communication activities in particular seeking to incorporate lay-public input (Goodfellow et al., 2011). No doubt, engagement of local authorities and members of the public through consultation, panel meetings, newsletters, etc, during the site selection assessment are a must to build consensus on the political game inherent to the siting decision.

3.5. Overcoming the resistance

Again, the question arises: what would opponents do to voice their views against the construction of a HLW facility? Despite the number of demonstrations and rallies taking place around the country since the Fukushima crisis, the survey shows that political engagement in Japan remains weak and opposition is mainly passive. In effect, only about 12% of the respondents would be

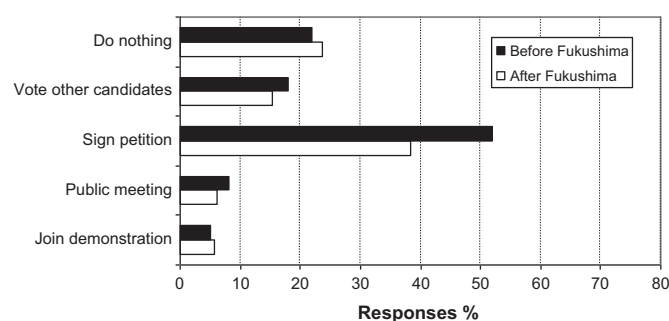


Fig. 5. What the Japanese youth would do against the construction of a nuclear waste repository.

inclined to participate in a demonstration or a public meeting, but would find more comfortable signing a petition or eventually doing nothing (Fig. 5). These results are in line with our previous investigation pointing to the fact that any support for local protests or an active role against the project is tempered by the responsibility of keeping social harmony. For others, the sentiment of doing nothing is just a reflection of frustration or simply the belief that no difference will be ever made. It is relevant to note however, that a passive attitude does not mean acceptance, although it is only people strongly against the facility who would actively oppose the repository construction. In short, the survey indicates an absence of vocal opposition or the so-called “NIMBY protest” as defined by Dear (1992), even when few people would still support the construction of a waste facility in their area.

Government officials effectively use financial rewards and compensation in order to overrule local opposition and discontent (Lesbirel, 1998). The present survey suggests that only a substantial compensation might minimise the NIMBY reaction of the potential host communities. The public appears to show a relatively good acceptance of the HLW facility, but most would not want to live in its proximity. Nearly 70% of the respondents said they would accept the construction of a HLW facility if it is beneficial for the country. However, only 26% would agree with the disposal facility in their

residential area, even if the community is compensated for the burden. The number of respondents willing to accept the siting if the compensation is directly distributed among families is similar. All of these figures are in line with results previous to the Fukushima crisis, where the percentage of people willing to accept a neighbour HLW repository was significantly less than the support levels in a general situation.

Most respondents (~71%) eluded an answer when asked what kind of household compensation they would accept in exchange for the disposal. Those who did respond came up with amounts ranging from about \$10,000 up to disproportionate values of several millions. This context suggests that people do not have a clear understanding of what a reasonable compensation for an unwanted facility could be, or whether they would be willing to trade risk for any financial reward at all. It is hard to specify in advance which elements would minimise the NIMBY reaction, although an effective compensation package might require not only financial rewards but additional benefits such as subsidies, infrastructure, housing, etc. In effect, there exists a growing opinion that waste and other socially unwanted facilities tend to be located in poor and marginal areas (Llurdes et al., 2003) and therefore, communities in economically depressed localities might be less reluctant to host the siting of a waste facility. While inequities and pockets of poverty are not unknown in Japan, one of the main characteristics of the country is its socio-economic uniformity. This characteristic and the general favourable financial conditions of its citizens introduce additional challenges to narrow down a possible location for the waste facility. Following the basics of supply and demand, the high living standard of its people drastically reduces the bargain power of the government, forcing it to introduce policies that set the host community apart from the rest of the society. Unless the financial reward is undeniably high and therefore irresistibly, these policies should also accommodate other citizens' demands and welfare benefits to increase the chances of acceptance. Broken the resistance level of the area dwellers, the future would be more promising. As stated by Venables et al. (2012), it appears that over time, those living close to a potential risk may come to view it as a characteristic of life at that locality.

3.6. Limitations of the study

The present investigation has certain limitations that must be pointed out. First, the study is largely qualitative. This approach was considered appropriate for the examination of people's attitude but extra care had to be taken to avoid influencing the analysis by the authors' personal views. In spite of this, the conclusions of the present work rely entirely on the interpretation and expertise of the authors leaving thus, a door open for discussion. Second, the survey was undertaken in a relatively educated group of people, all of them within a similar age segment. As previously explained, the cultural and socio-economic homogeneity of the Japanese society means that the results can be safely extrapolated to the rest of the population. Nonetheless, there is no doubt that a larger and more heterogeneous sample would increase the confidence for generalisations. Third, responses from the poll provide a snapshot of people's perception at that time, and are likely to change along with shifts in the lifestyle, social, political, financial and environmental context of the country. In line with the idea of Siegrist and Visschers (2013), the geographical location of the nuclear accident is certainly important. The closer an accident or hazardous facility to the respondents' hometown, the different the perception. Finally, further study is needed to deal with greater complexity and assess the influence of other variables in the responses provided.

4. Concluding remarks

The disposal of radioactive wastes and the formulation of energy-production policies are intrinsically shaped by the public perception towards the technology. The failure of the Fukushima reactor was a breakthrough point in the history of nuclear energy, with the consequent effect on people's attitude and its implications for the development of the radioactive waste programme in Japan. In this regard, a study was conducted to gain a better insight into how the public perception and acceptability of a disposal facility evolved following the events at Tohoku in March 2011. Following the authors' previous investigations and for comparisons purposes, the study assessed the results of an opinion survey responded by university students after a lecture on HLW in Japan. In its interaction with the audience, the lecturer presented background information about geological disposal but trying to avoid any subjectivity that could have influenced the students' perception.

The present study found an increase in the knowledge of spent nuclear fuel and its disposal with respect to previous years, although about 1/3 of the respondents still expressed their lack of awareness on the option for building a waste-storage facility. The position about nuclear power and its secondary products appeared to have dramatically shifted following the Fukushima crisis, ranking now above the most concerning issues for the Japanese youth. The fear of leakage and contamination of soils and aquifers is widespread and it is possible that this perception is the main driving force behind people's attitude towards nuclear wastes. Furthermore, the loss credibility in the government and regulatory institutions has contributed to a growing scepticism on the management of nuclear wastes. In effect, there is a general consensus in Japan that the Fukushima crisis was plagued of mismanagements and that critical information has not been revealed to the public. In this context, the legitimacy of the waste disposal programme and its ulterior success will rely on the reconciliation between government agencies and the general public. Aside from the selection of a suitable repository site, policy makers and regulators must focus on rebuilding public confidence in the country's nuclear programme as a critical component for the acceptance of a future repository. The internet and social network are widely used by young generations and thus, they would constitute a powerful tool for the government and the scientific community to educate, engage and build a bridge in the relationship with the public. More interaction and communication between policy-makers, technical experts, and the general public appears to be mandatory for the nuclear future of Japan. Panel meetings to promote dialogue, distribution of newsletters and invitations for expressions of interest to comment and/or participate in the studies, regular public-opinion surveys, seminars, workshops and presentation of new results to the general public, and internet forums can all be useful mechanisms to engage stakeholders and members of the public during the development of the geological storage programme.

It is worthy to note that in spite of the hazards and distrust, more than half of the respondents expressed their willingness to accept a storage facility within the country. Nevertheless, the acceptability drops significantly when the siting has a more direct impact on people's life. While compensation policies and the provision of benefits might moderate the NIMBY phenomenon, a long-term and systematic communication process based on objective and transparent information, education, and a more open public participation would be crucial to reach a viable solution for the disposal of nuclear wastes in Japan.

Even when a number of uncertainties remain, the paper highlighted the position of the youth in relation to the siting of a nuclear waste repository in Japan. In a world trying to minimise

carbon emissions and being highly dependent on imports of fossil fuel, the migration of Japan from nuclear power to other sources of energy might not become a reality for many years to come. In this context, the present work gains more relevance and constitutes a useful reference for all involved with geological storage and the disposal of radioactive wastes.

Appendix A. Questionnaire

Section 1: General information

- Sex: Male/Female.
- Prefecture of origin.
- Knowledge of HLW previous to the lecture: knew/heard about it/first time.
- Regarding the geological repository: knew/heard about it/first time.

Section 2: From 1 to 10, rank the problems that most concern you, and where the authorities should devote further efforts

Economy; crime; international relations; taxes; HLW; nuclear power; environmental pollution; education; immigration; health and pension system.

Section 3: Feeling of dread

Response: very worried (4)/worried/almost not worried/not worried (1).

- Leakage of radiation from the repository and contamination of soil and waters.
- Accident at the facility.
- Accident during transport of radioactive wastes.
- Sabotage or terrorist attack to the repository.
- Contamination of food supplies in the region around the repository.
- Decline of property values in the region.

Section 4: Fear of different hazards

Response: very worried (4)/worried/almost not worried/not worried (1).

Crime; terrorism; traffic accident; economic collapse; unemployment; HLW; nuclear power; nuclear war; cancer; AIDS; global warming; ozone depletion; environmental pollution; earthquakes; floods; tsunamis.

Section 5: Feeling of trust

Response: believe (4)/tend to believe/difficult to believe/do not believe (1).

- The government will explain and provide details about the risk of HLW disposal.
- The government will select the proper site for storage.
- Scientists working on HLW disposal are reliable.
- When choosing a disposal site, the government will give priority to people's safety over economic benefits.
- Authorities will quickly disclose any accident at the facility.
- Authorities will respond effectively to an accident.

Section 6: Trust in authorities

Response: strongly trust (4)/trust/distrust/strongly distrust (1).

- Prime Minister.
- The Congress.
- Prefecture government.
- Municipal government.

Section 7: Acceptance

Response: Strongly agree (4)/ agree/ disagree/ strongly disagree (1).

Do you agree with the placement of a HLW repository in Japan? If "yes", do you agree with the placement of a HLW repository in your city or prefecture?

How would you oppose/support the repository construction?
1. Join public demonstrations; 2. attend public meetings; 3. sign petitions; 4. In the next election, vote for a candidate that oppose/support the repository construction; 5. do nothing.

- I will accept the repository construction if it is beneficial for the country.
- I will accept the repository construction near my place of residence if my community receives compensation.
- I will accept the repository construction near my place of residence if me/my family receive compensation.

If "yes" what compensation are you willing to accept?

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