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Societal issues in a context of radiation protection

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Abstract

Ionizing radiation is part of a series of current societal concerns, together with climate change, pesticides, GMO or chemical pollution. Common points of these concerns are, on the one hand, that many uncertainties remain regarding their health and environmental effects, which is quite logical since not enough time has passed to assess their long-term effects, and, on the other hand, that huge financial interests are at stake.
In this context, we see a proliferation of experts' quarrels, leading to a loss of credibility of the experts in general. The reasons for this are analysed in this article, the 100 mSv "case" serving as an illustration (this level of dose is frequently presented as a "level of concern", if not as a "threshold", for radiation effects on human health). Beside conflicts of interest, the fundamental issues challenging experts' work are: limits and misuses of the evidence-based approach, lack (or refusal) of precautionary attitude in scientific research and scientific reductionism, all together causing an increasing gap with society.
The main challenge for (radiological protection and others) experts in the next 50 years could well be to change their own perception, instead of trying to change public's perception.

Societal issues at a glance

Ionizing radiation is part of a series of current societal concerns, together with climate change, pesticides, GMO or chemical pollution. Common points of these concerns are, on the one hand, that many uncertainties remain regarding their health and environmental effects, which is quite logical since not enough time has passed to assess their long-term effects, and, on the other hand, that huge financial interests are at stake. Now highlighting or creating doubts is a method frequently used by the industrial and financial lobbies as a strategy for delaying political decisions potentially unfavourable for them. The result of this is a proliferation of experts' quarrels, all the more so since conflicts of interest are also present in a number of international organisations in charge of giving scientific advises. The corollary of this is a loss of credibility of the experts in general.
Beside these conflicts of interest, other fundamental issues are challenging experts' work, including in radiological protection: the limits and misuses of the evidence-based approach, the lack (or refusal) of precautionary attitude in scientific research and the scientific reductionism, all together causing an increasing gap with society.
The 100 mSv "case" will serve as an illustration of these (frequently hidden) issues that will be explored more in detail in the second part of this article.

The 100 mSv case

The figure of 100 mSv has been arbitrarily chosen by international organizations as the upper limit of the so-called "low doses" of ionizing radiation. But it is also frequently presented as a "level of concern" for radiation effects on human health, several experts or organizations maintaining that, under this level, the possibility of "any health effect" is "purely hypothetic".
There are several formulations for presenting this 100 mSv level of concern, all claiming being "purely scientific", while some of them accepting that the system of radiological protection may (or should) be based on the assumption that there is no threshold for radiation-induced stochastic effects (cancers and hereditary effects).
As an exemple, in the 2005 report of the Académie Nationale de Médecine (France), the following statement can be read: « les études épidémiologiques disponibles ne décèlent aucun effet pour des doses inférieures à 100 mSv, soit qu'il n'en existe pas, soit que la puissance statistique des enquêtes ait été insuffisante pour les détecter…Une relation linéaire décrit convenablement la relation entre la dose et l'effet cancérogène pour les doses supérieures à 200 mSv où on a pu la tester ».
In a position statement in 2010, the Health Physics Society writes: "below 5–10 rem (50-100 mSv) (which includes occupational and environmental exposures), risks of health effects are either too small to be observed or are nonexistent".
In current discussions in UNSCEAR, several experts state that "*unequivocal attribution*" (meaning: with 100 % certainty) of *health effects* to ionizing radiation is *impossible* under 100 mSv. They justify this statement by the fact that 100 mSv is currently the first statistically significant point in the dose-effect relation for all solid cancers together in the gender- and age-mixed population of the Japanese survivors to the atomic bombing (LSS) and that there are no other individual epidemiological studies where the evidence is strong enough to draw 100% certain conclusions.
It is worth underlining that these formulations give overwhelming importance only to epidemiology (and within this only to "strong epidemiological evidence"), while *consistency of the corpus of knowledge* coming from all epidemiological studies and from all concerned disciplines (including radiobiology) is an important part of a balanced scientific assessment. Another characteristic of these statements is that the epidemiological evidence concerning radiation-induced solid cancers in a mixed population is generalized to all types of health effects and populations.

Before analyzing further the reasons of these statements regarding the 100 mSv figure, it is worth reminding ourselves, by some examples, that there *are* evidences of health effects induced by exposures under 100 mSv, not only for cancer induction, but also for some non-cancer health effects.

In utero exposures and childhood leukaemia

The association between childhood cancer and childhood leukaemia and antenatal exposure to X-rays by obstetrical radiography has been demonstrated since many years (the first, and largest, case-control study was the Oxford Survey of Childhood Cancers, which started in UK in the early-1950s, and continued until 1981, including more than 15 000 case-control pairs), and, in spite of many discussions, is still considered as solid evidence. Indeed, the association has now been confirmed by many case-control studies carried out around the world and the association is now accepted as real, although some remain skeptical of a causal interpretation (Wakeford, 2013). This skepticism is mainly due to the finding that the relative risk of childhood leukaemia and that of all the other typical cancers of childhood are raised to a similar extent, unlike the pattern of risk when exposure occurs after birth, and to the absence of leukaemia cases among the A-bomb survivors irradiated in utero. However, only about 800 of these survivors received a dose of more than10 mGy while in utero (the average dose was 0.25 Gy), so only around 0.2 case of childhood leukaemia would be expected in the absence of exposure on the basis of mid-20th century Japanese national rates , and there is also the possibility that cases of childhood leukaemia incident during the 1940s, before systematic collection of data began in 1950, may have gone unrecorded or have been overlooked (e.g. because the involvement of leukaemia in an infectious disease death had not been recognised in the difficult years following the end of the war) (Wakeford 2013).
In addition, a study on A-bomb survivors exposed in utero suggests that the lymphoid cells at origin for childhood leukaemia could be particularly sensitive to cell-killing. Extensive cell-killing at moderate or

high doses of these cells (as in A-bomb survivors) suppresses the risk of leukaemia, while the risk would still exist at lower doses (as after abdominal diagnostic x-ray examinations) (Ohtaki, 2004).

The last BEIR report (BEIR VII) concludes that « studies of prenatal exposure to diagnostic X-rays have, despite long-standing controversy, provided important information on the existence of a significantly increased risk of leukaemia and childhood cancer following diagnostic doses of 10-20 mGy in utero ».

Similarly, in a recent (december 2012) report on Childhood leukaemia and environmental factors, a joint group of the Health Council of the Netherlands and the Superior Health Council of Belgium concluded that: "On the basis of epidemiological and laboratory research as reviewed by international and national experts, prenatal and postnatal exposure to ionising radiation contribute to the incidence of childhood leukaemia. Because of this, the Committee considers a causal relation between exposures to ionising radiation and childhood leukaemia as established. In addition, the Committee supports the view expressed by several multidisciplinary Committees of scientists that this holds for all types of ionizing radiation, and that there is no exposure threshold below which an increase in leukaemia risk is absent."

This case is particularly illustrative of the divergences between experts' approaches, some claiming that a causal association is still not scientifically "proven" (and as a corollary refusing taking these studies into account for challenging the 100 mSv figure), others considering that accumulated multidisciplinary evidence is strong enough for drawing "science-based "conclusions.

Childhood cancers: new low dose data

The Pearce study (2012)

This retrospective cohort study included patients without previous cancer diagnoses who were first examined with CT in National Health Service (NHS) centres in Great Britain between 1985 and 2002, when they were younger than 22 years of age. Data for cancer incidence and mortality were also obtained from the NHS Central Registry. To avoid inclusion of CT scans related to cancer diagnosis, follow-up for leukaemia began 2 years after the first CT and for brain tumours 5 years after the first CT. A positive association was noted between radiation dose from CT scans and leukaemia (excess relative risk [ERR] per mGy 0·036, 95% CI 0·005–0·120; p=0·0097) and brain tumours (0·023, 0·010–0·049; p<0·0001). Compared with patients who received a dose of less than 5 mGy, the relative risk of leukaemia for patients who received a cumulative dose of at least 30 mGy (mean dose 51·13 mGy) was 3·18 (95% CI 1·46–6·94) and the relative risk of brain cancer for patients who received a cumulative dose of 50–74 mGy (mean dose 60·42 mGy) was 2·82 (1·33–6·03).

The authors consider their results support extrapolation of the dose-effect relation observed in the LSS to the doses from CT scans (tens of mGy).

The Kendall study (2012)

It is a record-based case-control study of natural background radiation and the incidence of childhood leukaemia and other cancers in Great Britain during 1980–2006 (28 000 cases). They found an ERR of 12% (95% CI 3, 22) of childhood leukaemia per mSv of cumulative red-bone-marrow dose from gamma-radiation, supporting the extrapolation of high dose-rate risk models to protracted exposures at natural background exposure levels.

Although comforting a number of evidences showing a higher sensitivity of children to the radiation-induction of cancer (and particularly of leukaemia and brain cancer) and although good accepted by the scientific medical community, these studies were heavily criticized by several experts during the last UNSCEAR meeting due to the fact that some confounding factors may still exist. In the Pearce study, lack of information about indications for the CT scans (e.g. head trauma may have conferred risk) and the lack of individual dosimetry were strongly underlined. Kendall's study was criticized because of the uncertainties associated with using an ecological measure of dose and a crude, ecological measure to adjust for socioeconomic status.

These new studies have of course some limitations, as probably all studies. Nevertheless, they join a series of similar studies, giving *collective* findings that are comforting current assumptions lying at the basis of the radiation protection system (linear or linear quadratic relation in the low dose area). The important point is that this aspect was not all underlined, while overwhelming weight was given to any possible bias.

Cancer-proneness:

There are a lot of human genetic disorders affecting DNA-repair genes and cell-cycle regulation genes.
A retrospective cohort study has been conducted linking exposure to diagnostic radiation and risk of breast cancer among carriers of BRCA1/2 mutations (Pijpe 2012).
In this large European study, "*any* exposure to diagnostic radiation before the age of 30 was associated with an increased risk of breast cancer."
For such populations, we are far under the 100 mSv level.

In utero irradiation during first days of pregnancy and non-cancer effects:

After irradiation during the pre-implantation period, generally considered as safe with regard to the radiation-induced risks (at least for surviving embryo's…), non-lethal congenital malformations have been induced in animals, particularly (but not only) in those with a genetic predisposition to specific congenital malformations or with genetic disorders in the pathways of DNA-repair. There are similarities with the effects of some chemical agents (Jacquet, 2013).
Interestingly, during the zygote-stage (about 1 day), there could be no threshold dose for the radiation-induction of congenital malformations in genetically predisposed animal strains. Indeed, the energy needed for inducing DNA-damage in a particular cell is tiny and , in such cases, the cause of the congenital malformations cannot be an increased loss of cells (classic deterministic effect) but rather the persistence of un-repaired or mis-repaired DNA-damaged cells ("teratogenically damaged cells").

Now, in humans, genetic susceptibilities also exist. There are families showing clusters of spontaneous congenital malformation. There are also in humans many genes implicated in the DNA-damage response and involved in the genetic susceptibility to cancer induction by irradiation; if the mechanisms are similar (persistence of mis-repaired DNA-damaged cells), it is plausible that human genotypes leading to cancer-proneness are also associated with a genetic susceptibility to the radiation-induction of congenital abnormalities (or more subtle tissue dysfunctions).

In this case, there is no "proven" effect at low dose, certainly not in human beings (where obviously, no experiments can be done). But at least these studies should raise doubt about the "definite" and generalized character of a 100 mSv threshold dose for lethal, developmental or other deterministic effects after irradiation during the first trimester of pregnancy, currently applied by many as a practical criterion. This could be an unjustified simplification.

Low dose effects are biologically consistent

Tumorigenesis is currently viewed as multistage model, with mutations as a driving force.
It begins with damage to DNA and failure to correct this damage, which causes an initiating mutation (in a single target stem-like cell in most tumours). While cellular environment is crucial for promotional growth, further stages (conversion to malignant phenotype and tumour spread) are driven by further mutations.

Many genes are involved in the response to DNA-damage (DNA-repair genes, cell-cycle regulation genes) and the puzzle is not yet assembled. The important point is that some pathways for DNA-repair: are error-prone and that even the « error-free » pathway (homologous recombination) will unavoidably lead to mutations in some cases. Indeed this last pathway uses as reconstruction model the template of the other parental copy (homologous chromosome). Problem is that, in heterozygotes, if the good allele is damaged, the copy will be that of the bad allele (which is called "loss of heterozygoty")! And we are all carrying "bad" (recessive) alleles. It's the reason why you best not marry somebody of your close family! As a consequence there will unavoidably be some losses of heterozygoty when a large number of individuals are irradiated, with a probability increasing with increasing dose.

Radiation-induction of cancer: overall judgments

As mentioned earlier, giving overwhelming importance to epidemiology alone (and within this only to "strong epidemiological evidence") should be avoided. Consistency of the corpus of knowledge coming from all studies and from all concerned disciplines (including radiobiology) is an important part of balanced scientific information.

Contrary to the currently increasing importance given to the 100 mSv figure, international organizations were frequently more balanced in their judgment.

Let's remember this important statement in the UNSCEAR 2000 report: "Par 541. Until the above uncertainties on low-dose response are resolved, the Committee believes that an increase in the risk of tumour induction proportionate to the radiation dose is consistent with developing knowledge and that it remains, accordingly, the <u>*most scientifically defensible approximation*</u> of low-dose response. However, a strictly linear dose response should not be expected in all circumstances". (UNSCEAR 2000, annex G)

Similarly the BEIR VII report concludes: "The committee concludes that *current scientific evidence* is *consistent with* the hypothesis that there is a linear, no threshold dose-response relationship between exposure to ionizing radiation and the development of cancer in humans."

Finally ICRP writes in its last recommendations: "64) Although there are recognized exceptions, for the purposes of radiological protection the Commission judges that the weight of evidence on fundamental cellular processes coupled with dose-response data supports the view that, in the low dose range, below about 100 mSv, it is scientifically plausible to assume that the incidence of cancer or heritable effects will rise in direct proportion to an increase in the equivalent dose in the relevant organs and tissues."(ICRP 103)

<u>**Why does the 100 mSv "myth" revive?**</u>

There is compelling evidence that there are observable effects (well below) under 100 mSv, and consistent biological explanations. Then why is there a tendency, particularly these last years and in some international organizations, to repeatedly come back and lay stress on this 100 mSv figure?

As already mentioned, there are obviously conflicts of interest, exacerbated by the potential consequences of the nuclear accidents of Chernobyl and Fukushima that could lead to the use of strategies of doubt, allowing minimizing the health consequences of these accidents.

Nevertheless, other factors also play an important role, among which the

- The misuse of the evidence-based approach, by focusing only on the avoidance of unjustified causal associations (false positives) and neglecting the possibility of unjustified dismissal of real health effects (false negatives)
- The misunderstanding of the precautionary principle, considered not relevant in science
- And the interference with some value judgments often considered as "evident" in the scientific circles, facilitating self-censorship, due to the pressure of dominant paradigms and of the peers.

Conflicts of interest

Potential conflicts of interest are unavoidable for many countries – as they have been responsible of major radioactive contaminations in the past (or could be in the future…) - and many international institutions whose official mandate is to promote some practices (as the pacific use of nuclear energy).
Also worrying is the fact that almost all research work is financed by these interested countries and institutions.
Self-censorship is then the easiest way to avoid problems….It is much more comfortable and safe to follow the herd.
Scientific independence is a moral duty but also a difficult financial challenge.

Misuse of the evidence-based approach: what is "being scientific"?

Evidence-based approach is currently become a dominant scientific paradigm, particularly in the medical field, where it is the condition of agreement of any new drug and even of any treatment.
The basic concern is to avoid concluding that a causal relationship exists before it is strongly proved (hard evidence is required).
In other words, the main concern is avoiding the "false positives".
Current dominant pressure of this paradigm leads some experts or groups to consider that this way to proceed (to avoid carefully false positives) is the only way compatible with science, which is based on the possibility of testing and falsifying any hypothesis.
They use as an argument that the scientific method is based on the principle that there is an underlying order to the nature of things, and that by following certain rules and guidelines this nature can often be revealed. Ideas (hypotheses) are generated from observations and then tested by controlled experiments or observational studies, lending to better understanding (empirical science). Yet the problem is that, particularly in the current world, new things (or situations) are introduced rapidly but have possibly long term consequences, unknown by definition, asking for vigilance and responsiveness for early indications of health effects. Potential observations may be only possible after a long time, generating hypotheses at a late stage, whose testing (if feasible) may again take a long time. But decisions frequently are to be made about these new introduced things (or situations), while strong evidence or certainty is lacking. Such decisions must be based on available "evidence" (evidence, here not in the sense of "certainty", but in the sense of"indications" or "corpus of knowledge"), even if there persists uncertainties. Decision-makers need a sound basis for informed decision-making and are asking scientific experts (groups, committees …) for science-based balanced information, including science-based inferences.
These science-based inferences are sticking to scientific observations and are part of the scientific work. They are not "external to science" while decisions based on these inferences are "external to science".

This very fundamental conceptual issue is currently the object of animated discussions at the level of UNSCEAR, that, as a committee, tends these last years to give overwhelming importance to the avoidance of false positives, by highlighting all possible bias for an association between effect and exposure, in comparison with the avoidance of false negatives, while possible dismissal of real health effect of radiation is a major concern for responsible decision-makers. This attitude lies at the basis of the minimized risk estimates of UNSCEAR regarding the health effects of Chernobyl: there is indeed no "100 % certainty" for many of these effects.

There were recently some important changes. The UNSCEAR's strategic objective for the period 2009-2013, endorsed by the General Assembly, in its resolution 63/89, is "to increase awareness and deepen understanding among authorities, the scientific community and civil society with regard to levels of ionizing radiation and the related health and environmental effects as a sound basis for informed decision-making on radiation related issues". Now, UNSCEAR underlined in its last report to the General Assembly (A/67/46, paragraph 23), that "this strategic objective highlighted the need for the Committee to provide information on the strengths and limitations of its evaluations, which are often no fully appreciated. This involves avoiding unjustified causal associations (false positives) as well as unjustified dismissal of real health effects (false negatives)." Formally it is an important step forward (by the way, suggested by the Belgian delegation). Unfortunately the culture is far to have changed in a large part of this committee, and the debate is still raging.

Misunderstanding of the precautionary principle:

Precaution is relatively largely accepted regarding decision-making processes in situations of uncertainty (although the definition of this concept may be very different).
The point here is that the precautionary approach is also relevant and appropriate in science! This is frequently misunderstood.

As underlined in the COMEST report from UNESCO, the precaution approach in science includes:

- a focus on risk plausibility rather than on hard evidence
- a responsiveness to the first signals ("early warnings")
- a systematic search for surprises ("thinking the unthinkable"), particularly for possible long term effects

The first point is linked with the previous discussions concerning misuses of the evidence-based approach. For society the main concern of the experts is expected to be the protection of health. When there is scientific *plausibility* ("enough evidence") of the existence of a risk of serious harm, action is needed. Even if there is still uncertainty!
In other words, the main societal concern is avoiding the false negatives.
Precaution in science means in fact focusing on (or at least giving attention to) risk plausibility and not only to hard evidence.

The corollary is the need of being vigilant and responsive to the first signals of potential health problems ("early warnings"), as for example is the rule for vigilance about drugs.

Recent developments regarding the late recognized radiation effects of low to moderate doses on the lens of the eye and on the circulatory system are good illustrations of a lack of vigilance and responsiveness regarding early warnings that were described many years ago.

Systematic search for surprises ("thinking the unthinkable") is a more difficult challenge, because it means often challenging dominant paradigms or at least refusing to "follow fashion". It may seem strange or incredible but there are fashions in the scientific world. Example in the current radiation specialists' field is the quasi total lack of interest about hereditary effects, judged frequently as being practically inexistent or negligible just because nothing was seen until now (some tens of years …) in the survivors of the atomic bombing. Bad surprises may arrive in this field in the future. The same is true concerning non-cancer effects after in utero irradiation, where the dominant concept is currently that there is nothing to fear under 100 mGy, while the domain of internal exposures and of long term effects linked to epigenetic effects, as gene expression, is practically unexplored (with a few exceptions).

In this respect, it is worth mentioning the recent EC report on "Recent scientific findings and publications on the health effects of Chernobyl" (Radiation Protection No 170, 2011).

This report opens the discussion on the issue of the controverted reasons of children's morbidity in the most affected areas around Chernobyl.
There are many claims concerning the health of children in the contaminated territories around Chernobyl, which seem to suffer from multiple diseases and co-morbidities with repeated manifestations. The reports from international organizations did not give until now much interest in the multiple publications by Ukrainian, Russian and Byelorussian researchers on children's morbidity. This is partly due to the fact that many of these studies were not available in English but also to the fact that they often did not meet the scientific and editorial criteria generally required in the Western peer reviewed literature.
Anyway, all these health problems were collectively qualified as "psycho-social" by the UN agencies.

More or less recent studies brought again this issue into light, including the debated publications of Bandazhevsky, linking ^{137}Caesium body loads with ECG alterations and cardiovascular symptoms in children such as arterial hypertension, and the studies on neurobehavioral and cognitive performances in children of the contaminated areas.
To verify these observations, IRSN conducted series of animal studies. Rats were exposed to ^{137}Caesium contamination during several months (generally 3 months, sometimes 9) through drinking water containing 6500 Bq/L. Intake of ^{137}Caesium was estimated to be 150 Bq/day/animal (500 Bq/kg of body weight), a figure that is considered by the authors to be comparable with a typical intake in the contaminated territories (based on Handl's evaluation in Ukraine: 100 Bq/day with variations, according to geographical location and diet, from 20 up to 2000 Bq/day as in the case of special dietary habits like excess consumption of mushrooms) .
Although the animals tested in these studies did not show induced clinical diseases, a number of important biological effects were observed on various systems: increase of CK and CK-MG, decrease of mean blood pressure and disappearance of its circadian rhythm; EEG modifications, perturbations of the sleep-wake cycle, neuro-inflammatory response, particularly in the hippocampus, etc.
It must be underlined that these somewhat *unexpected* results are obtained after relatively modest intakes of ^{137}Caesium and that a fraction of the population in the contaminated territories has been shown to incorporate ten times more ^{137}Caesium with their food.
On the ground of the fact that there is a currently a lack of analytical studies in which dose and risks on non-cancer diseases in children were estimated on an individual level, a series of longitudinal studies have also been initiated recently in Ukraine in conjunction with the US University of South Carolina and were devoted to children's health, making use of the fact that all children in the studied territory had been obliged to participate in a yearly medical examination.
A first study investigated, for the years 1993 to 1998, the association between residential soil density of ^{137}Caesium (used as exposure indicator) and blood cell concentrations in 1251 children. The data showed a statically significant reduction in red and white blood cell counts, platelet counts and haemoglobin with increasing residential soil contamination. Over the six-year observation period, hematologic markers did improve. The authors draw the attention on the fact that similar effects and evolution were reported after the Techa River accident in 1957.
A second study investigated, for the same years 1993 to 1998, the association between residential soil density of ^{137}Caesium and spirometry measures in 415 children. They found statistically significant evidence of both airway obstruction and restriction with increasing soil ^{137}Caesium. The authors advance as possible explanation a radiation-induced modulation of the immune system leading to recurrent infections and finally to detrimental functional effects.
Series of other studies are announced. The authors of these studies conclude by saying that the current "optimism of the UN reports may be based on too few studies published in English, conducted too soon after the event to be conclusive".

Internal exposures: thinking the unthinkable

For chronic internal exposures, a major underlying issue could thus be the adequacy of the equivalent and effective dose as general risk indicator.

It is important to realize that there are still major uncertainties regarding the assessments of risks induced by internal contaminations. The simple use of the concept of effective dose and its calculation through the dose conversion factors (Sv/Bq) may be misleading for risk assessment (IRSN 2005, CERRIE 2004), as illustrated by Müller's experiments on embryos in the preimplantation stage: due to the highly heterogeneous distribution (specific incorporation within DNA), ^{3}H-thymidine, for example, is between 1,000 and 5,000 times more effective (to produce deleterious effects) than HTO when the same activity is applied! These effects are still more pronounced using ^{3}H-arginine (histone precursor). We should be more cautious before claiming that some results are not acceptable, just because they cannot be explained by the conventionally calculated dose.

Value judgments:

Last but not least, is it simply possible to be « purely scientific »?
Science cannot avoid ethical issues, some of them being deeply imbricated (and often not seen) within the area of the scientific work. There are many examples of value judgments within scientific assessments (management of epistemic uncertainty, just or sound character of assessments, selection of consonant sources, "importance" or "triviality" of a risk, …).

Even in some uses of the precautionary approach, an overwhelming importance is given to quantitative criteria, like risk probabilities, compared with qualitative ones, as quality of live. In an interview concerning the consequences of the accident and the countermeasures, an inhabitant of Fukushima considered decontamination of forests as destruction of his "forefathers' legacy": a totally other dimension than just a question of trees that can be replaced.

Current scientific paradigm is based on a mechanistic vision of the world, considering quantification as the only way for accessing to the reality. In a holistic vision of the world, hard science observations (and limitations), human sciences, ethics and spirituality are articulated and are all considered as necessary for understanding the reality and for justifying responsible decision-making (Frederic Lenoir).

Objectivity and the club spirit

As we have seen, "purely scientific" judgment is a kind of modern illusion, as science cannot avoid interferences with ethical and epistemological questions. Science cannot escape from some intrinsic subjectivity. In an attempt to control this, one often appeals to consensus as a guarantee for objectivity.
Doing so, one forgets that scientists, coming from the same melting pot, spontaneously favour cognitive consonance and share the same interpretative language, the same paradigm (a whole of reference presuppositions, which are often unconscious).
On these grounds, interpretations of reality are not seen by them as subjective and have in their eyes an indisputable value.

Stakeholder involvement is the appropriate remedy for avoiding club thinking, allowing new views and perspectives to emerge and favouring creative thinking about mechanisms, scenarios or implications.

Unfortunately stakeholder involvement is currently often just a façade. The invited stakeholders and experts are very few and their opinion often considered as irrelevant and hardly taken into account. The "official" experts consider themselves as the "real" experts, in charge of informing the others and eventually to modify their wrong perception.

Conclusion: at a glance

Faced with a growing loss of credibility in the population, the main challenge for (radiological protection and others) experts in the next 50 years could well be to change their own perception, instead of trying to change public's perception.

« Ce qu'il faut à présent, c'est réconcilier en nous les deux démarches (science et conscience); non pas nier l'une en faveur de l'autre, mais faire en sorte que l'œil qui scrute, qui analyse et qui dissèque vive en harmonie et en intelligence avec celui qui contemple et vénère… «
Hubert Reeves

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