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Safety and Health Concerns for the Users of a Playground, Built with Reused Rotor Blades from a Dismantled Wind Turbine

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Abstract: This paper analyses the user safety of a playground built out of reused blades from a dismantled wind turbine. Located in Rotterdam and designed by the Netherlands architecture firm Superuse Studios, the playground, called "Wikado", represents an example of the circular economy applied to the built environment. With reused materials, Wikado represents a saving in resources and energy, when compared to a standard playground built with primary materials. Furthermore, the playground creates a unique design experience for its users, who can still recognise the original rotor blades following their transformation into slides, platforms, and tunnels. However, the safety of the playground could be questioned. This paper will analyse the materials and products used in the playground and their condition some years after opening. The analysis focuses on the risks of human health during the use of the playground. It considers the shape and the sharpness of the rotor blades, its components such as glass fibres and epoxy resin. As a result of the analysis, two risk analysis conceptual models help to assess the health concerns regarding the contact with the materials, and some yellow drops leaching from the rotor blades. This analysis informs the contemporary debate concerning the reuse of materials, and more generically, the circular economy applied to the built environment: whether it is recommended and safe to reuse materials for a different function from that which they were originally designed. This paper will explain that in the analysed case study, it can be safe to reuse materials for a different function, but only with the appropriate precautions.

Keywords: materials reuse; circular economy; wind turbine; sustainable design; circular design; sustainable architecture; human health risk assessment

1. Introduction

Background

The playground "Wikado", designed by the Dutch architecture firm Superuse Studios [1], opened on the 10th of October 2008 in the city centre of Rotterdam, The Netherlands. Wikado is a merger of the terms "Mikado", a Japanese game with sticks, "wiek", the Dutch word for a windmill blade, and "kado", the Dutch word for gift or present. The playground was built with used blades from modern wind turbines and other reused and recycled materials. A Netherlands company providing engineering services, called NGup Service B.V. [2], originally manufactured the rotor blades. The blades were mounted and operated on a wind turbine, then after fifteen years they were demounted and stored in a deposit near Almelo in The Netherlands (Figure 1).

Figure 1. Rotor blades stored on a field before being transformed in components for the playground ('03.02.12-Wind Turbine Blades' by 'kristinefull' is licensed under CC BY-SA 2.0).

In 2008 another Netherlands engineering company called Maropol [3] transported the rotor blades to the building site of the playground. The blades had a layer of paint applied by NGup. Maropol cut, shaped, and then assembled the blades as components of the playground. During the construction phase of the playground, Maropol used epoxy resin and glass fibres to coat some broken parts of the blades and provided some of the finishes. Finally, Maropol coated several parts of the playground equipment and the caretaker applied a layer of white paint and some coloured stripes (Figure 2) on the entire playground. In summer 2009, some months after the opening of the playgrounds, the caretaker of Wikado applied an additional layer of paint onto the surfaces of the wind turbines. In 2011, Superuse Studios (at the time called 2012 Architecten), the designers of the Wikado playground asked Piero Medici to investigate a specific issue occurring uniquely on that project and help to propose a solution. The research was supervised by Césare Peeren, partner of Superuse Studios, and published in two reports [4,5].

Figure 2. The "Wikado" playground, composed of rotor blades painted in white with coloured stripes (Photo by Carolyn Butterworth, 2011).

2. Materials and Methods

2.1. Materials Applied

The ingredients of the materials composing the playground are crucial elements for assessing its safety. Others are the maintenance and a schedule regarding when to renew the components.

NGup, the original equipment manufacturer of the rotor blades, did not disclose the exact ingredients of the rotor blades. It was, however, established by a shareholder at NGup that the materials composing the rotor blades were primarily epoxy resins and glass fibres with some Polyurethane (PU) foam and possibly some hardener added to the epoxy resin [6].

In 2011, an employee of Maropol disclosed some specific information about the materials' ingredients that his company used for the finishes of the playground. Materials were mainly: epoxy resin type THV 500 and 600, expanding two-component PU foam (35 kg/m^3), and glass roving (glass fibres) in various weights. A manager from Maropol explained that the rotor blade edges cut by Maropol were too sharp, and that he smoothed these by applying epoxy resin combined with glass fibres. Furthermore, Maropol used epoxy resin with glass fibres to cover holes and scratches on the blades and to connect cut parts. The rotor blades had been industrially manufactured to perform under extreme conditions. For this reason, the type of epoxy resin used by NGup for the blades could be different from the resin used by Maropol for the finishes on-site. The caretaker of Wikado painted the playground with a two-components solution: paint (i.e., Sigmetal Aquacoat, by Sigma coatings [7], and a hardener by the same brand, composed of epoxy resin and *2,3*-epoxypropyl neodecanoate. To increase the users' grip on walkable surfaces, the caretaker used a mix with two-quarters of paint, a quarter of hardener, and a quarter of sand.

2.2. Inspections

From July to September 2011, the main author, together with the caretaker of Wikado and three professionals from different industries, conducted some site visits and inspections of the playground. The first professional was a manager of Maropol, who was involved in the construction phase of Wikado; the second was a specialist of surface treatment from Cornet Groep; and the third a manager from Luijten vvz [8]. The latter two Netherlands companies are specialised in coatings and paint. During the visits, the condition of the materials, the surfaces, and edges were all assessed. The group observed that yellow drops were leaching from the blades, and analysed the consistency and the state of the substance by touch and with a cutter. The author visited the playground three times, the first time with the caretaker, the second time with a manager of Maropol, and the third time also together with the specialist of surface treatment from Cornet Groep (Table 1). In the first visit, the author took pictures and samples of the playground surfaces, focusing on damaged parts and on the leaching. One of the outputs of the inspections was the decision to apply an additional layer of coating and paint to the entire surface of the playground.

Table 1. Time schedule regarding opening, inspections, and maintenance of the Wikado playground.

Date	Event
2008	Opening of the playground and application of the first external layer of paint by the caretaker
2009	Application of the second external layer of paint by the caretaker
2011, July 21st	Inspection of the playground by Piero Medici, the caretaker
2011, July 25th	Inspection of the playground by Piero Medici, the caretaker, Maropol
2011, August 25th	Inspection of the playground by Piero Medici, the caretaker, Maropol, Cornet Groep
2011, September 21st	Inspection of the playground by the caretaker, Cornet Groep, Luijten vvz
2012	Application of a new external layer of primer and paint

2.3. Scope of This Paper

This paper focuses on the first three years of the life of the playground, before the application of the additional layer of coating and paint during late 2011 (Figure 3). The research presented assessed possible health risks for the users of Wikado and the strengths and weaknesses of its design, concerning the reuse of components and materials. It analysed the history of Wikado, the construction phases, the origins of the materials, and the condition of the playground. The paper will try to respond to the question if it is safe and appropriate to reuse the rotor blades for a children's playground. This was executed through literature research, interviews with specialists of coating and paints, stakeholders, and site visits. As a result of the analysis, the paper defines two risk analysis conceptual models, which will contribute to assessing the health concerns of the users, also when compared to a standard playground design.

Figure 3. The playground Wikado after the application of the new external layer of coating and paint in 2012. Most of the components of the playground are reused rotor blades, such as the four towers, and the six parts lying horizontally. (Photo by Denis Guzzo, 2014).

3. Results

3.1. Health Risks for Users Related to Glass Fibres

To assess the safety of Wikado from 2008 to 2011, it is useful to take as a reference the playground equipment standard valid at the time (NEN-EN 1176-1) [9]. The European Standard EN 1176-1 [10] was the first part of the international standard for playgrounds, named "Playground equipment and surfacing". It was implemented in the Netherlands as NEN-EN 1176-1 [9] on the 1st of June 2008. Chapter 4.1, called "General safety requirements and test methods" regarded the safety requirements for the materials. Subection 4.1.5, about synthetics, states: "If during maintenance, it is difficult to determine at what point material becomes brittle, manufacturers shall indicate the time after which the part or equipment should be replaced. It should be possible for the operator of the playground to visually identify excessive wear of the gel coat of glass-reinforced plastics (GRP) products intended for sliding before the user becomes exposed to the glass fibres [9] (p. 16)." Following the standard NEN-EN 1176-1, in a playground such as Wikado, it is essential to give an indication of the time after which the parts have to be replaced. Furthermore, it has to be possible to visually identify excessive wear of the coat before the user becomes exposed to the glass fibres. However, in Wikado neither NGup, Maropol, nor Superuse Studios scheduled the maintenance and the lifetime of the components. As in the standard NEN-EN 1176-1 [9], since glass fibre is one of the ingredients of the rotor blades, it is essential to avoid its exposure to users. The standard NEN-EN 1176-1 [9] refers specifically to glass-reinforced plastics products intended for sliding. Even if the blades were not specifically used as slides in a more conventional sense, the users could still run, sit, and slide on their surfaces.

3.1.1. Site Visits

The main author visited the playground three times with different professionals (Table 1) to analyse the state of the blades. In the visits, the author took pictures and samples of the playground surfaces, focusing on damaged parts. These parts were documented and analysed as possible sources of risk for the users' health to be assessed in a human health risk assessment conceptual model (1).

At the time of the site visits, which was three years after Wikado's opening, some parts of the blades were already brittle (Figures 4–12) and some parts of the glass fibres were exposed, sharp, and with the potential to cut the skin when being touched on site. Both glass fibres of the rotor blades by NGup and glass fibres used by Maropol were used for the finishes. During the visits to Wikado, it was observed that the glass fibres had the potential to come into contact with the users, especially on two locations of the blades. The first location faced the entrance of the playground in the street called Tochtstraat, and it had a height of a typical step (Figures 7 and 8). The glass fibres were exposed, most likely because users often stepped on the edge of the blade. These glass fibres probably belonged to both the finishes by Maropol and the blades manufactured by NGup. In the same location (Figure 7), some polystyrene had also detached from the edge.

Figure 4. Interior of a rotor blade where finishes are cut and brittle as a consequence of the use by children. The interior of the blade is accessible; some parts are more than a metre high, where a young child can stand and walk. (Photo by Piero Medici, 2011).

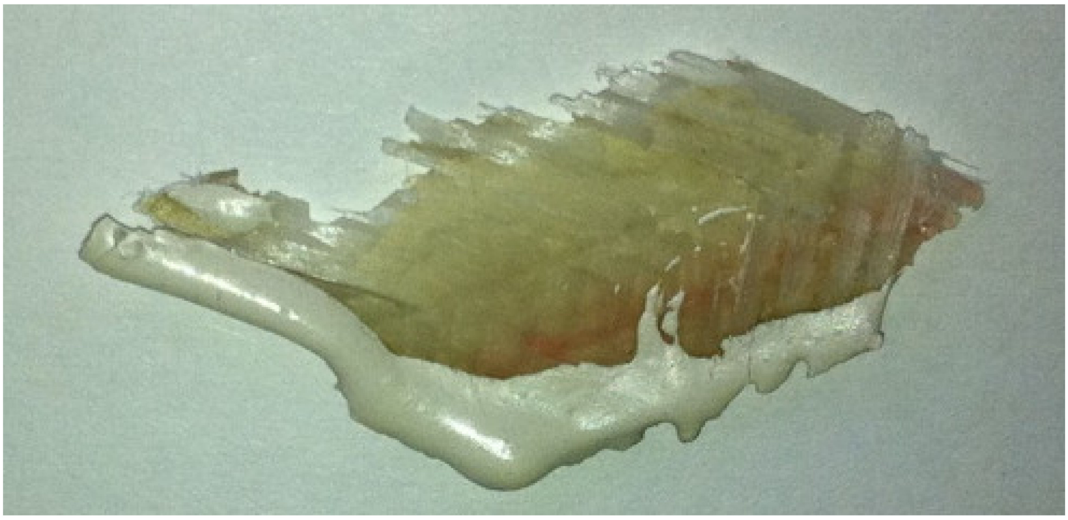

Figure 5. Piece of sharp finish of glass fibre, epoxy and white paint coating, a sample from the location illustrated in Figure 4 (Photo by Piero Medici, 2011).

Figure 6. Close-up of finishes with epoxy resin, glass fibres and white paint coating. In the right part of this picture the spot is visible where the piece of Figure 5 was removed (Photo by Piero Medici, 2011).

Figure 7. Edge of the rotor blade already brittle with polystyrene coming out, as a consequence of the users walking on it (Photo by Piero Medici, 2011).

Figure 8. Edge of the blade already brittle, with glass fibres and parts of the coating exposed to the users (Photo by Piero Medici, 2011).

Figure 9. Damaged finish by Maropol, with glass fibres exposed, as a consequence of use damage (Photo by Piero Medici, 2011).

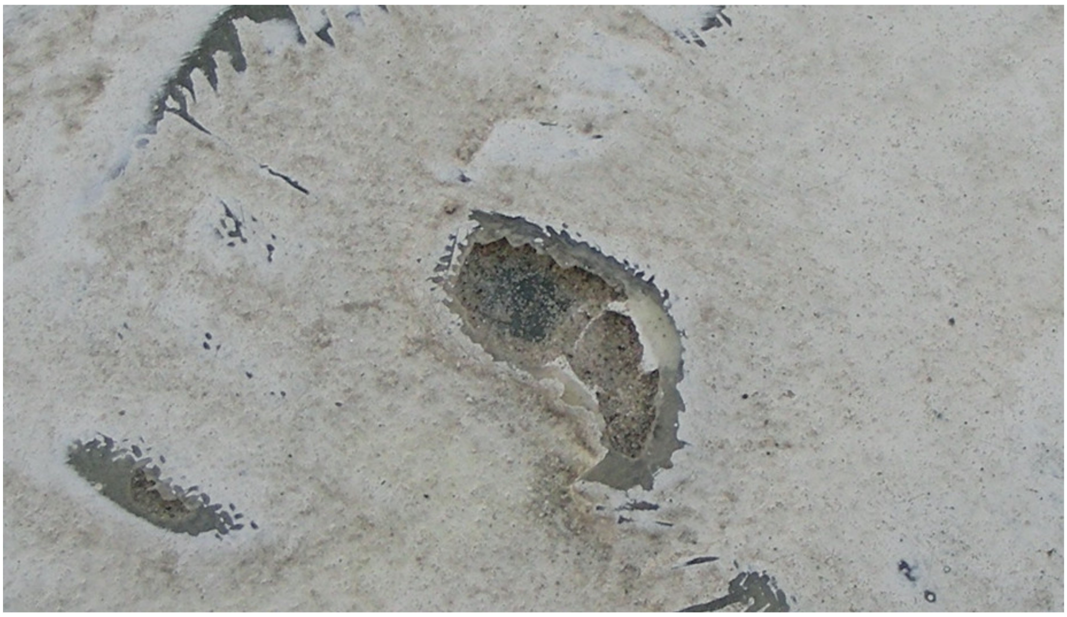

Figure 10. Damaged and sharp surface of a blade, as a consequence of the users walking and playing on it (Photo by Piero Medici, 2011).

Figure 11. Detail of a finish and coating by Maropol (Photo by Piero Medici, 2011).

Figure 12. Brittle edge of a blade, sharp on the top-right part of the picture, where the epoxy resin and the glass fibres are damaged (Photo by Piero Medici, 2011).

The second location, where the glass fibres and the epoxy resin were exposed, was inside one of the hollow blades (Figures 4 and 6). These glass fibres belonged to the finishes by Maropol. It was established that this part was quite sharp and that it should have been smoothed out. A small piece was removed as a sample for investigation. It was sharp at the touch, and the glass fibres, the epoxy resin, and the white paint coating (Figure 5) were apparent.

3.1.2. Safety Concerns

The first conclusion of the visits was that the glass fibres, present in the original rotor blades by NGup and in the finishes by Maropol, could be harmful when exposed to the users. A human health risk assessment of the playground can be defined as the interaction between sources (S), pathways (P), and targets (T):

$$R = S \times P \times T \quad (1)$$

Following this formula, it was possible to trace a conceptual model (Figure 13) of glass fibres representing a health risk when exposed to the users [11–14]. The risk assessment model was derived from literature regarding Human Health Risk Assessment and human exposure to chemicals [11,12].

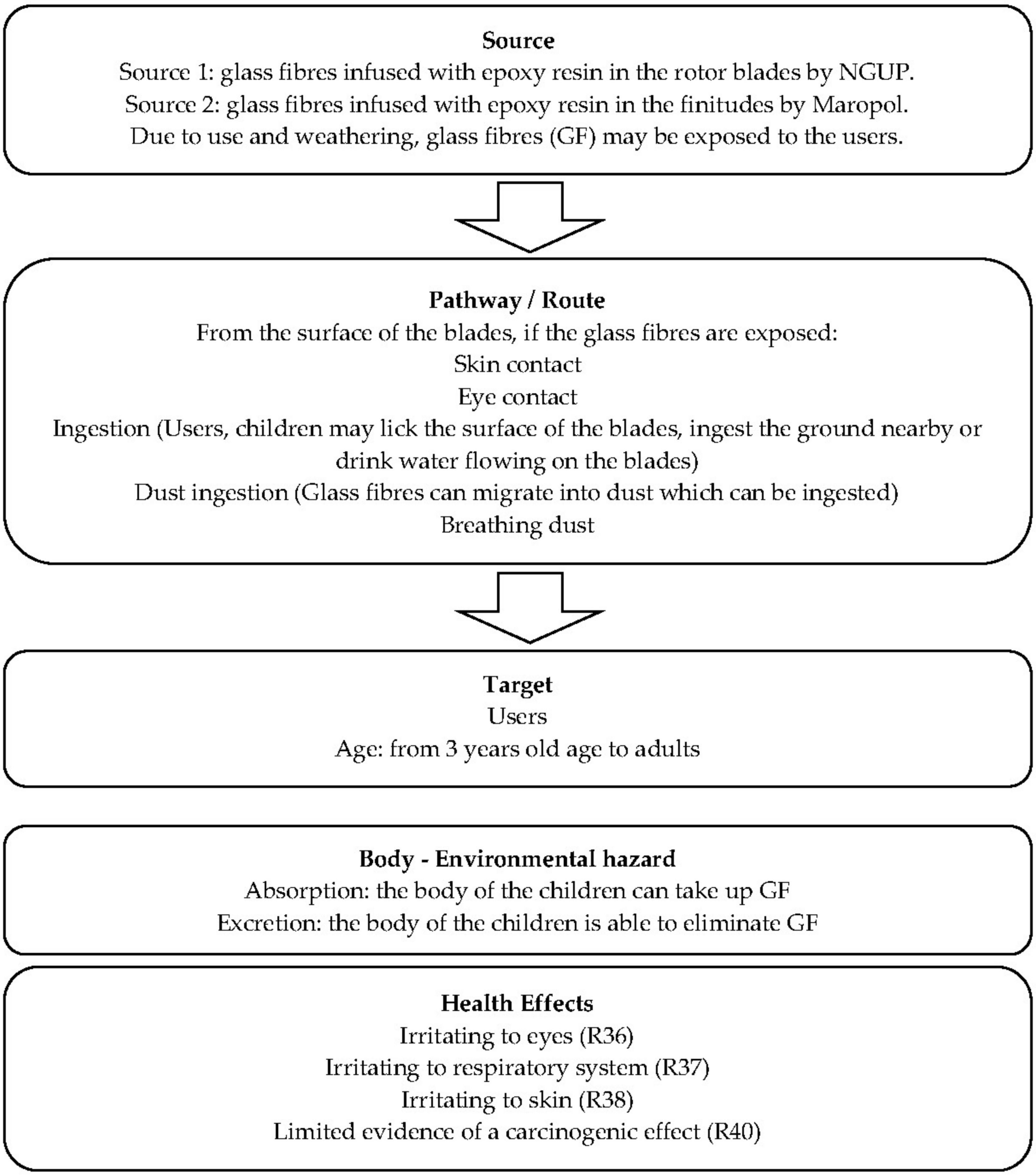

Figure 13. Conceptual model of risk assessment regarding glass fibres.

The primary risk for the users of the playground is the contact with the exposed glass fibres that are sharp and able to cut the skin. If the glass fibres were exposed massively, the playground users could inhale or eat thin parts of them. The human skin could absorb particles of glass fibres, causing an irritation known as fibreglass dermatitis (an article entitled "Fiberglass Dermatitis" stated that "the most frequent health hazards due to glass-fibre exposure are represented by skin lesions, commonly known as fibreglass dermatitis. The basic pathogenetic mechanism of fiberglass dermatitis is represented by penetration of fine, sharp particles into the skin causing mechanical irritation. It is one of the most common occupational irritant contact dermatitis. From a clinical point of view itching (usually very strong) and tingling sensation usually represent the early symptoms. A diffuse eruption of small erythematous patches together with papules of small diameter can be observed in the most of the cases ... [15,16] (p. 65)"). Since particles of the glass fibres could also reach the lungs through breathing, they are suspected of causing respiratory irritation and even cancer [13,14,17–19]. In Wikado the health risks concerning these severe diseases are highly unlikely since the amount of glass fibres exposed is minimal.

3.2. Health Risks Related to the Coating and Epoxy Resin

During the inspections in the summer of 2011, a light-yellow substance was observed, similar in appearance to light oil, leaching on the surfaces of the blades, a large amount of which was on the blade standing on its longer edge (Figures 14 and 15), and a smaller amount on the other blades. It was observed that most of the drops were leaching down from parts close to the finishes applied by Maropol. The most apparent leaching was located on the north-west elevation of the blade standing on its longer edge (Figures 14 and 15). The drops seemingly leached down from the top, where the coat by Maropol was located. A smaller amount of leaching was located on the surface oriented to south-east of the same blade (Figure 16). The leaching also was apparent on the towers of the playground, which were built with blades as well. The drops were leaching from the top of the towers (Figure 17) and were more visible on the southern side exposed to the sun. The leaching was also clearly visible on the jointure by Maropol between the blades (Figure 18). A large amount of the light-yellow leaching was located on one of the blades lying horizontally on its wider surface. It seemed that the blade worked as a gutter for precipitation, which probably carried and accumulated part of the yellow leach at the end of the blade. In addition, during one of the visits, a child's toy bucket had been placed on the edge of a blade, collecting water, which could be drunk, from the fountain located on the top of one of the towers (Figure 19). Before reaching the bucket, the water flowed along the surface of the blade (Figures 20–22). In July 2011 most of the yellow drops were quite dry and solid to the touch by hand and when cut with a cutter (Figures 23–27). The yellow liquid, contained in the water from the fountain collected on the blade (Figure 20), could be assessed only through a laboratory analysis test. The European Standard for playgrounds EN 1176 [10] states that substances that can cause adverse health effects to the user of the equipment shall not be used in playground equipment. Therefore, if, for example, the state of the drops is liquid in some periods of the year, and if the liquid contains substances that can cause adverse health effects, the playground would not comply with the directive. A laboratory analysis would be required to know the exact liquid ingredients.

Figure 14. Leaching on the surface facing north-west of the blade standing on the long side (Photo by Piero Medici, 2011).

Figure 15. Drops leaching along the north-west surface of the blade standing on the long side (Photo by Piero Medici, 2011).

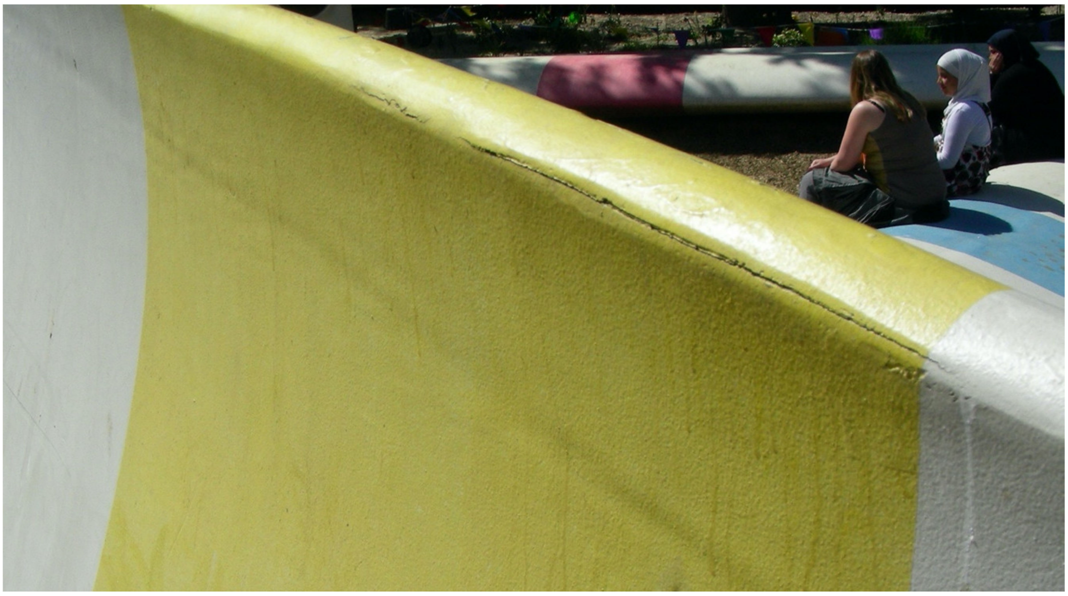

Figure 16. Leaching on the surface facing south-east of the blade standing on the long side. Drops seemingly coming out from an opening of the coating by Maropol (Photo by Piero Medici, 2011).

Figure 17. Leaching from the top of a tower (Photo by Piero Medici, 2011).

Figure 18. Leaching next to the joints by Maropol (Photo by Piero Medici, 2011).

Figure 19. Trace along the blade working as a rain gutter. A red toy bucket is located on the blade and on the left bottom part of the picture a tea cup is visible (Photo by Piero Medici, 2011).

Figure 20. Blade lying horizontally working as a rain gutter, a yellow leach is visible (Photo by Piero Medici, 2011).

Figure 21. Water flowing on the blade, from the fountain located on top of the tower (Photo by Dennis Guzzo, 2014).

Figure 22. Close-up of the drops, on a blade lying horizontally (Photo by Piero Medici, 2011).

Figure 23. Leaching below a blade lying horizontally (Photo by Piero Medici, 2011).

Figure 24. Close-up of the drops next to a surface opening (Photo by Piero Medici, 2011).

Figure 25. Drops leaching down, close-up (Photo by Piero Medici, 2011).

Figure 26. Drops leaching below the blade, close-up (Photo by Piero Medici, 2011).

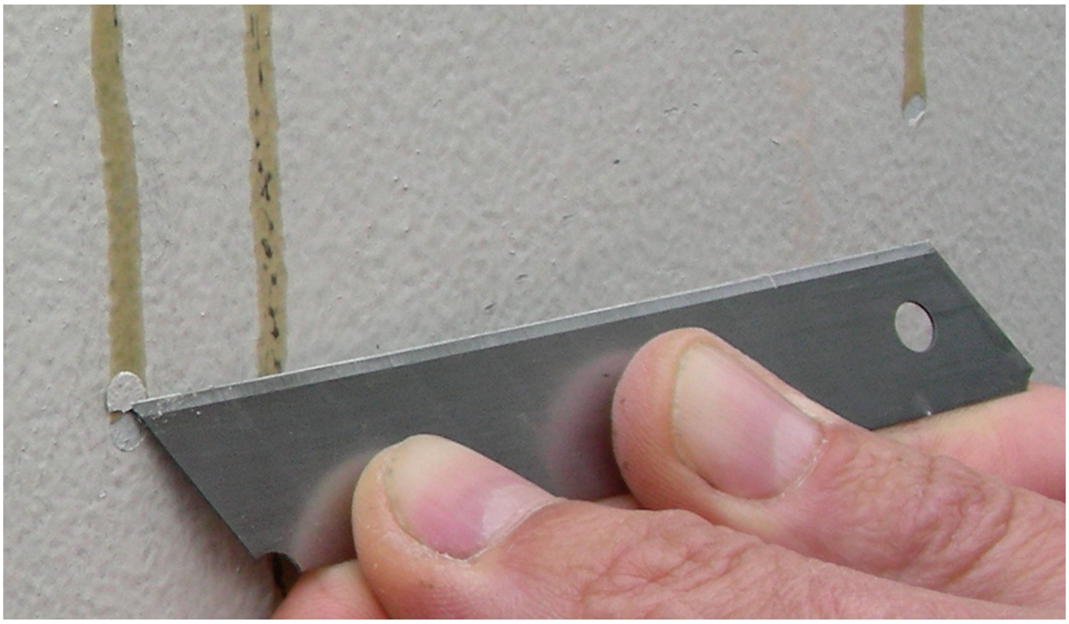

Figure 27. Test with the cutter on the surface of the blade standing on the short side; some paint is attached to the detached drop (Photo by Piero Medici, 2011).

The caretaker of the playground explained that he painted the blades when the playground was first opened, and after six months the leaching came out on the blade standing on its longer edge. After some time, he noticed that the yellow drops were leaching down on the blades once again. Then, he repainted the blades, and after some more months, the leaching started again. The caretaker mentioned that on the other blades, leaching began 18 months after the construction of the playground.

3.2.1. Site Visits

The author visited the playground three times with different professionals (Table 1) to analyse the leaching. In the visits, the author took pictures and samples of the playground surfaces, focusing on the yellow drops that were leaching. The leaching was documented and analysed as a possible source of risk for the users' health and assessed in a human health risk assessment conceptual model (2).

Since the inspections took place during the summer months, the temperature was approximately 20 degrees Celsius, and the weather was cloudy but not raining. The drops were quite dry and solid to the touch. During one of the visits, a cutter was used to test the consistency of the drops (Figure 27). On the blade standing on the short side, the drops were quite solid, dry, and sometimes slightly sticky. Drops were removed using the cutter and they were found to be firmly attached to the white paint, with a thin layer of paint sticking to the detached drops. In another part of the playground, with two blades stacked on top of each other, the drops were less dry, but still quite firm (Figures 24–26). In the playground, the drops were generally quite solid and only sometimes slightly sticky. The inspecting group agreed that it could have been useful to test the consistency of the drops on the wet playground after a day of heavy rain and after a warm sunny day. If, under these conditions, the leaching would be more liquid, the users could accidentally touch and ingest the drops through hand to mouth behaviour or even direct licking.

The professionals from Maropol, Luijten vvz, and Cornet Groep declared that they had never experienced similar leaching in a similar context before. However, they assumed the leaching was derived either from the blades by NGup, the finishes by Maropol, or the paint by the caretaker. They expected that the drops could contain epoxy resin. The epoxy resin could derive either from the blades by NGup, the finishes by Maropol, or from the hardener of the paint by the caretaker. Another hypothesis was that the paint of the caretaker reacted with the epoxy resin applied by Maropol and caused the leaching. Other causes could be related to the type and the temperature of the epoxy resin applied by Maropol.

The specialist in coating and paint from Cornet Groep concluded that the drops were not coming from the paint used by the caretaker. He explained that the paint was water-based and the hardener, which contained some epoxy resin, was white and with a consistency similar to the colour. He expected that the drops were leaching from a yellow resin with a denser texture. He stated that the drops derived from the epoxy resin of Maropol. However, he did not understand why the paint by the caretaker was not able to keep the epoxy resin underneath. The manager from Maropol asserted that the drops might derive from the reaction of the paint applied by the caretaker with the coating by Maropol or the original blades by NGup, while Cornet Groep was less convinced by this view. Only with a laboratory analysis of the drops and knowing all the ingredients of the blades would it be possible to know the origin of the drops.

The authors of this paper estimated that the drops did not derive only from the exterior paint of the caretaker because their amount was higher, near the cuts and finishes, where the layer applied by Maropol was exposed to the air. Without a chemistry laboratory analysis and disclosure by the manufacturer of the exact ingredients of the rotor blades, it is challenging to state if the materials composing the blades by NGup were part of drops. However, it has to be considered as a possible hypothesis. In addition to that, it was noticed that there was a larger amount of leaching on the sides of the blades exposed to the sun, which was often of a more intense yellow colour. On the other sides, more exposed to the north, there were fewer drops, that were of a darker colour. The reaction on the sides exposed to the sun could happen through photolysis [20], with the solar light contributing to transforming the colour of the epoxy resins to yellow. Rainwater and other weathering conditions might help to degrade some types of epoxy resins through hydrolysis [21,22] and to migrate the leaching along the surface of the blades.

3.2.2. Safety Concerns

Regarding the possible human health concerns for the users, the yellow drops of Wikado could contain epoxy resin. This is because the epoxy resin was present in the original rotor blades by NGUP, in the finitude made by Maropol (type THV 500 and 600), and in the hardener of the painting applied by the caretaker. He used three quarters paint and a quarter hardener composed of epoxy resin and *2,3*-epoxypropyl neodecanoate (Figure 28a,b).

(**a**) (**b**)

Figure 28. (**a**) Paint used by the caretaker; (**b**) hardener applied by the caretaker (Photos by Piero Medici, 2011).

In general, if the epoxy is dry and stable, it is supposed to be safe for human health, since it cannot be easily absorbed by skin or ingested. During the inspections of Wikado, the yellow drops seemed quite dry; only some were slightly stickier. For children, the risk of ingestion could be higher. The ingestion could be caused by hand-to-mouth behaviour and contact with the water from the fountain flowing on the blades. A conceptual model of risk can be useful to clarify the potential dangers of epoxy resin in contact with users [11,12]. Also, in this case, a human health risk assessment is defined as the interaction between sources (S), pathways (P), and targets (T):

$$R = S \times P \times T \quad (2)$$

Following this formula, it was possible to trace a conceptual model (Figure 29) with the epoxy resin representing a health risk for the users of Wikado. Considering the rotor blades as a probable source of epoxy resin, the epoxy resin could be a risk for the health of the users when the yellow drops are present on the blades due to wear, use, and atmospheric conditions [23,24].

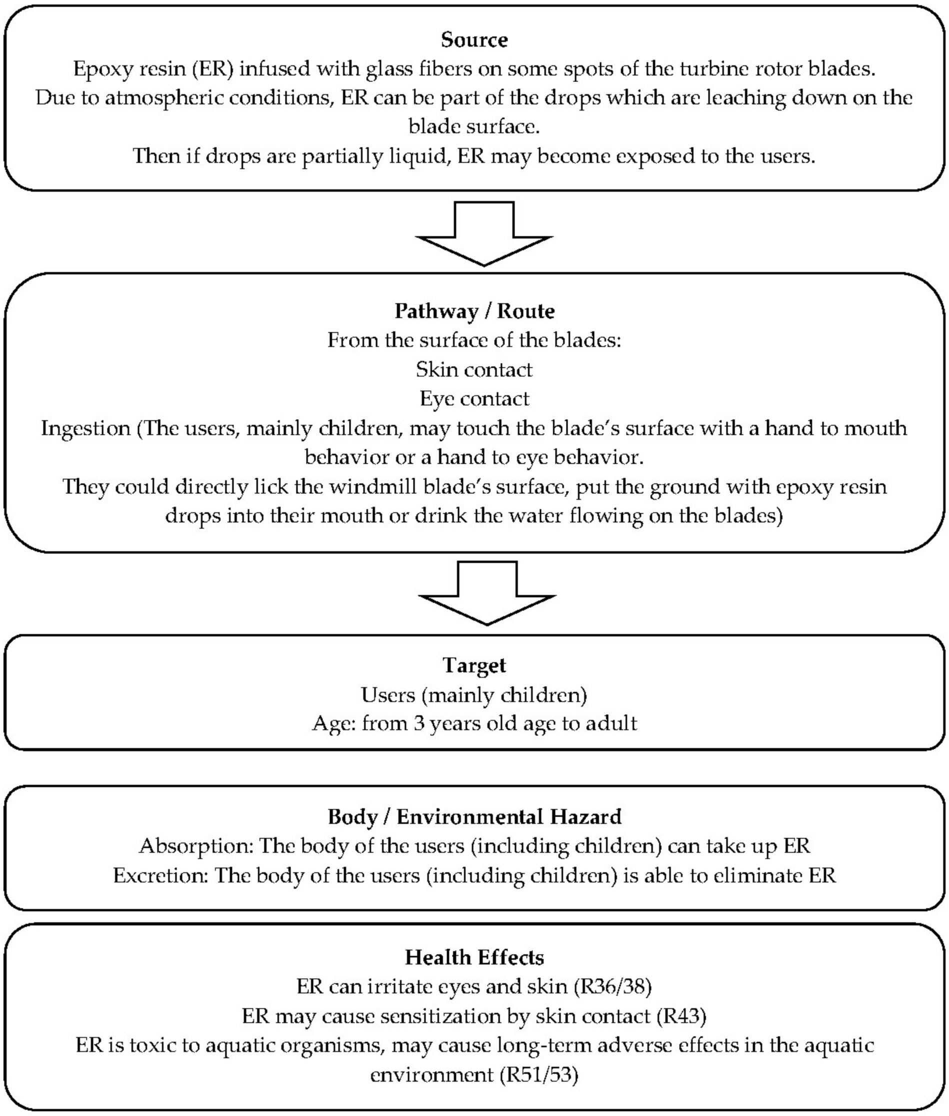

Figure 29. Conceptual model risk assessment of epoxy resin from Wikado's wind rotor blades.

The risk model was used as a guide to give an overview of the possible sources, routes, and targets of the epoxy resin. The table also lists the body hazard and health effects related to epoxy resin. The goal of this paper was not to provide the precise amount of chemicals released and absorbed, nor exact estimations of health effects, which would be obtainable only through several laboratory analyses, but to highlight the leaching as an unplanned effect and the unwanted consequences.

During the site visits, the drops were relatively dry, not sticky, not liquid, therefore difficult to be absorbed by the body through skin contact or ingestion. Due to the state of the drops, Cornet Groep supposed that the physical contact of the users' hands and the playground was generally safe. Cornet promised to consult a specialist of Sigma coatings [7], a paint manufacturing company, regarding the most proper paint or coating to apply on the surface of Wikado to cover and fix the leaching. The manager from Maropol suggested that the probability of having a harmful amount of toxic volatile organic compounds (VOC) coming out from drops was low. However, to be sure of the absence of any danger, the group of visitors recommended a laboratory analysis of the drops. The manager from Maropol suggested taking a sample from the ground where the water dropped after flowing on the blade. He proposed to do it after a couple of sunny weeks and after throwing some water on the surface of the blade. This is because the sun and the rain can deteriorate the epoxy.

The authors assume that since the playground is outside, the rainwater or other forms of precipitation could contribute to the hydrolysis of the epoxy resin and the epoxy coating. Hydrolysis is a chemical process where a molecule is divided into two parts by the addition of a molecule of water. It is the type of reaction that is used to break down specific polymers [21,22]. Hydrolysis could also take place where the drinking water, released from the fountain on the top of one of the towers, flows onto the rotor blades. A child could potentially drink that water, after collecting it with a toy bucket. Outdoor conditions also make photolysis possible. Photolysis is a photochemical process in which such cleavage is an essential part [21,25]. The European Standard for playgrounds EN 1176 [10] states that substances that can cause adverse health effects to the user of the equipment shall not be used in playground equipment. The Standard EN 1176 [10] refers to the Directives 76/769/EEC [26], 67/548/EEC [27], which list dangerous substances including the ones toxic for reproductive purposes (The European Standard for playgrounds EN 1176 refers to the directive 76/769/EEC, which states: "Liquid substances or preparations, which are regarded as dangerous according to the definitions in Article 2 and the criteria in Annex VI, Part II. D to Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances, as last amended by Directive 86/431/EEC, may not be used in: ornamental objects intended to produce light or colour effects by means of different phases, for example in ornamental lamps and ashtrays; tricks, jokes; games for one or more participants, or any object intended to be used as such, even with ornamental aspects [26] (p. 5)").

In Wikado, hydrolysis and photolysis can potentially detach a substance with the chemical name bisphenol-A-(epichlorhydrin), epoxy resin [28] (abbreviated to BPA). BPA is an endocrine disruptor, suspected of damaging fertility or unborn children—classified as "possible risk of impaired fertility" [22,29]. In Wikado, the amount of BPA that could leach from the epoxy resins is most likely too small to be of concern for the health of the users [22]. It is, however, an example of a substance that could be released and be potentially harmful.

4. Conclusions

Wikado represents an interesting, sustainable, circular solution in terms of design and reuse of components and materials. Improvements can be made, however, concerning the health and safety of the users. These issues can be solved by sharing the required information regarding the materials and defining a maintenance schedule during the design process. It is essential to meet such requirements when reproducing similar spaces in the built environment. In the context of the circular economy, it is crucial to re-define strategies regarding the reuse of materials and resources.

Well-defined practice and procedures are required to safely reuse components and materials for a different function than that for which they were originally designed. Knowing the exact constituent materials of the components is fundamental to predict the possible range of chemical reactions within the materials as a result of use and weather conditions. Once the correct ingredients are established, it would be possible to test the different combinations of materials with appropriate coatings and paints. By adopting similar practices and precautions, the actors involved in the design process and the construction of the playground itself could avoid risks for the health of the users. It is indeed essential to avoid the egress of a sticky substance more or less wet leaching into or onto a playground. The reasons to avoid this are not only aesthetic but also concern possible irritation to skin, eyes, or internal organs if ingested. In the case of Wikado, given the amount and the solid state, the yellow drops are probably not toxic, but the only way to be sure would be a laboratory test. However, toxic or not, a playground for children should not release unscheduled yellow substances. Even in this case, to know the exact composition and the potential danger of drops and leaches requires a chemistry laboratory analysis. Directly after their discovery, Superuse Studios affirmed that the yellow droplets percolating from the rotor blades' fibre-reinforced polymer material were related to primer and paint applied by the contractor. Soon after, the rotor blades were cleaned and coated with suitable primer and paint, resulting in the yellow droplets no longer appearing.

In Wikado, the spaces where the children walk and play, inside and in between the hollow rotor blades, is unique. The blades, manufactured through a high-tech process, bring to the playground slender and exciting shapes. Some are standing on the ground, others lying, cut in pieces or preserved in their entirety. The blades can unlock the curiosity of the children, stimulating their knowledge regarding technology, sustainable energy, and the state of the planet. Furthermore, in Wikado, the embodied energy and the use of natural resources is lower compared to a standard playground (In 2011 as a researcher, I performed a Life Cycle Assessment of Wikado materials compared to a standard playground built with new materials [30,31]. The method consisted of the literature review, information provided by Superuse Studios and other stakeholders, calculations supported by software like CMCLA (Leiden University) [32] and SimaPro [33]). The blades came from a nearby location, and they did not require much reworking to be reused. In addition to that, reusing the blades is an ideal solution compared to recycling. Due to the complex structure of the blade and the composed materials being difficult to disassemble, recycling the blades is a challenge [6].

Wikado has embedded unique features in terms of aesthetics and energy. However, it has some issues that need to be solved before the concept can be replicated on a broader scale. The problems are mainly related to the safety and appropriateness of materials, in terms of shape and ingredients. Rotor blades may produce sharper parts and be more brittle after some use, compared to a steel slide or small wooden towers of standard playgrounds [31]. The coating and glass fibres of the blades may contain more hazardous chemicals compared to slides and tunnels of a conventional playground composed of epoxy resins and coatings.

Therefore, what cannot be left out is an analysis of the materials, their ingredients and properties, together with precise instructions about how to assemble, use, and maintain it. To accomplish that, an open and multi-stakeholder exchange of information must be available regarding the ingredients and properties of the materials among the different stakeholders. Free access to knowledge about how to disassemble and reassemble materials and components to build products and buildings with the same function of their first life or a new one is needed.

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