A Review on Isolation of Keratin Protein from Non-conventional Resources and Its Application in Daily Diet to Enhance Hair Quality

Priyanka Jana, Rudra P. Saha, and Arpita Das

Abstract Rather than dumping the big quantity of keratinous waste, in particular birds' feathers, demands greater fee-added application. To hold up body systems, protein is an important nutrient and also a critical factor for beauty merchandise. Chicken feathers contains excessive amount of keratin protein and also the right protein source. The hair, skin and nails (tissues) are made up through epithelial cells. Keratins are best protein called for imparting strength and resilience to cells that shape the hair, skin and nails. Those proteins also are allowed tissues to withstand damage from friction, minor trauma, which includes scratching and rubbing. It will be a great help for the society and industry if we can plan to insert these portions in our daily diet. Even though all of us recognize human's frame digest soluble keratin protein by using trypsin and pepsin (secretion of the leader cellular, pepsin, the proteolytic enzyme of the belly is normally chargeable for much less than 20% of the protein digestion which happens within the gastrointestinal tract). Ingesting this keratin protein complement someone can get all blessings of keratin protein. The existing paintings report the effects of experiments aimed at making ready water-soluble keratin. In this record, we are going to speak about techniques to prepare water-soluble keratin protein from non-conventional sours. In this, chicken feather is used, and we can speak about the techniques of extraction of soluble keratin protein from feathers.

Keywords Keratin protein · Non-conventional protein sources · Food supplement · Chicken feathers

1 Introduction

Whole world is facing various problems due to air pollution like sinus problems, allergies, scalp irritation and also hair loss. This can also happen in indoor. Volatile organic compounds (VOCs) are release in air by several households which people

P. Jana · R. P. Saha · A. Das (✉)
Department of Biotechnology, School of Life Science and Biotechnology, Adamas University, Barasat, West Bengal 700126, India
e-mail: arpita.das@adamasuniversity.ac.in

M. Mukherjee et al. (eds.), *Advances in Medical Physics and Healthcare Engineering*, Lecture Notes in Bioengineering, https://doi.org/10.1007/978-981-33-6915-3_40

use regularly. In this generation, almost everybody spends their most time in closed buildings which are controlled by artificial air environments. Cooling and heating systems are also released VOCs (Langer et al. 2008). VOCs are major pollutants in indoor air, and these pollutants are deposited on the scalp, hair which is causing the scalp irritation and also hair loss (Wang et al. 2007).The skin and hair are first barrier which exposed to the pollution. The large and small suspended airborne particles along with gaseous, smoke pollution deposit on scalp and also hair, which is the cause of the scalp irritation and damage hair. At mining and also construction region, activity is showing the particle matter (PM) in high concentration. The dust of mercury, lead, zinc and other heavy metals can affect the people who living beside the mining areas and also damaged their hair (Huang et al. 2012; Qu et al. 2012). Electromagnetic radiation which was created by cell phones can also be a reason of hair loss. A review paper shows a study, which is showing that a single-strand DNA breakage in root of human hair cells when it exposed to a radiation of mobile phones (Çam and Seyhan 2012). Hair loss can happen after changing the residence and also the workplace and a long travelling distance, exposure to dusty wind and strong sunlight or excess heat or cold, smoke, smog, construction and mining areas and also fertilizer and cement factories and oil rigs, petroleum transport. A research study shows that swimming pool water which is chlorinated can also be the reason of hair loss (Rajput 2015).

Although there is no escape from pollution, there are things which people can do to prevent damage their hair. They have to have keratin protein in their daily diet. Keratin protein helps to nourish hair which is also good for skin (Basita et al. 2018). This protein helps hair to prevent breakage, heat damage, frizz and also important for maintaining strong and healthy hair. Sources of keratin are deriving from surprisingly wide range of foods. It is because many vitamins, minerals and nutrients found in foods either fortify the keratin already present in the body or encourage its production and regulation. The sources of keratin actually reside in entire subgroups of foods. The following foods provide great sources of keratin: red meat, egg, salmon, almonds, nuts, blueberries, oysters, etc.

The global population which is growing too fast is changing the socio-demographics, which will increase the pressure on the world's expedients to provide different kinds of food. The huge order for protein which is animal-based is anticipated unfavourable on environment, which also generates emissions of greenhouse gas and requires area of land and water. So, crisis people need supplementary food, and the source should be non-conventional.

Chicken feathers contented huge amount of keratin protein and it is also a non-conventional source. While feathers are often considered as a by-product of poultry production (often a waste by-product). Chicken feather is bio-resource which content 750 g protein per kg crude and poultry factories produce a huge number of feathers, and also this large number of feathers burning is not economically effective. Disposal of feathers is also not environment friendly. Chicken feathers consist of approximately 90% keratin. The worldwide annual feather amount is about 8 × 105 tonnes (Grazziotin et al. 2006).

Depending on secondary structure, keratin proteins are divided into alpha-keratins and beta-keratins. Alpha-keratins are found in the hair, the skin and the wool of mammals. These are primarily fibrous and helical in structure. Beta-keratins occur in animal like reptiles and also in bird. The amino acid composition of keratin is varying, and it is depended on the tissue (Gupta et al. 2012). In a research, it was shown that keratin protein can be soluble, although we know that it is an insoluble protein. And this soluble keratin protein would extract from chicken feather (Sinkiewicz et al. 2017). In a explore, we institute the progression to all set a water-soluble and not poisonous protein consequent from keratin from sources of keratin such as brute hair, fur, feather, wool, hooves, horns, claws, shells, nails and keratinous materials such as meals organized from them. This water-soluble keratin protein is processed by hydrolysis (Kadri et al. 1976). So, a supplementary food product of keratin protein can be used as a good source of keratin.

2 Non-conventional Source

Keratin-based trash resources like wool and barren feathers of chicken are motivating investigations for people benefits. The fowl activity generates millions kg of discarded feathers of chicken apiece annum, which makes the down copious keratin source, which is discarded of by landfilling or ignition, and the contemporary disposal techniques through landfilling or ignition are not accordingly environmentally pleasant. Feathers and wool are the on the whole copious sources of keratin worldwide look for to their utilisation in the cloth and foodstuff industry, correspondingly (Li and Wang 2013; McGovern 2000). Wool is used in clothing industry, and the outcome is a load null of un-spinnable passing fleece rubbish. Wool is 95% keratin, of which 60 wt% is sappy keratin, and 26% is durable keratin . These feathers consist 90% of beta-keratin (Stiborova et al. 2016). The fowl manufacturing produces a colossal null sum of chicken fluff as uncultivated during meat making (Tesfaye et al. 2017).

Chicken down as the non-conventional stool pigeon of keratin compassion in humanity agricultural stated, in 2013, that 58 billion chickens are slaughtered apiece year. If we think 2 kg slaughter-heaviness of a chicken with 5–7% of fluff for each chicken, a least possible of 5.8 billion kg of feathers of chicken are fashioned apiece day as a by-product (Swetlana and Jain 2010). USA and India produce approximately 1.044 billion kg and 140 million kg chicken feathers, as become emaciated stuff for each year, correspondingly (Khardenavis et al. 2009). Two to three tonnes of chicken fluff bottle be fashioned by a slaughterhouse which processes 50,000 chickens apiece day (Gupta et al. 2012). According to Tesfaye, South Africa produces 258 million kg of feathers of chicken as a by-product as producing meat (Tesfaye et al. 2017). Insignificant amounts of these fluffs are second-hand as advantageous products, for low-value applications like innate nosh which expense about 13 rand and nourishment, and the other momentous portion is measured as a garbage note (Veerabadran et al. 2012). Feathers of chicken have about 90% keratin protein (Swetlana and Jain 2010). Keratin is extremely valued protein, and the cost of keratin from a human

being section sells for Rs-2840 for each gram. Hence, keratin can be able to extract from feathers of chicken which is converted into basic and worthwhile foodstuffs, and moreover, tin enhances beyond consequence and revenue to the capon industry. Biomedical applications are among the applications of keratin (Rouse and Dyke 2010; Kakkar et al. 2014).

3 Keratin Extraction Techniques

Keratin extraction is ended by contravention convincing disulphide bonds those crosslink keratin molecules. Depending on extraction technique, keratin chains may furthermore be shortened during the process (Ayutthaya et al. 2015). This segment describes extraction techniques of keratin from assorted sources. Keratin extraction methods may produce keratin proteins with uncommon substantial properties like viscosity, molecular load and other which anon have emotional impact properties of the decisive goods that will be created from keratin. The separate methodologies of keratin extraction technologies for waste chicken feathers are as follows:

3.1 Chemical Procedure of Keratin Extraction

It uses chemical substances to extract keratin from keratinous fibres. The mainly commonly used chemicals are sinking agents, oxidizing agents, ionic liquids, and (Sinkiewicz et al. 2017) hydrolysis extraction methodology requires an outsized sum of alkaline element compounds which includes sodium hydroxide (Rouse and Dyke 2010). Cysteine is actual finely turned to alkalis, and subsequently, the sum of cysteine decreases added hurriedly than lessening method. But the hydrolyzed keratin remnants unspoiled during the deal with. (McGovern 2000; Tsuda and Nomura 2014) (Fig. 1).

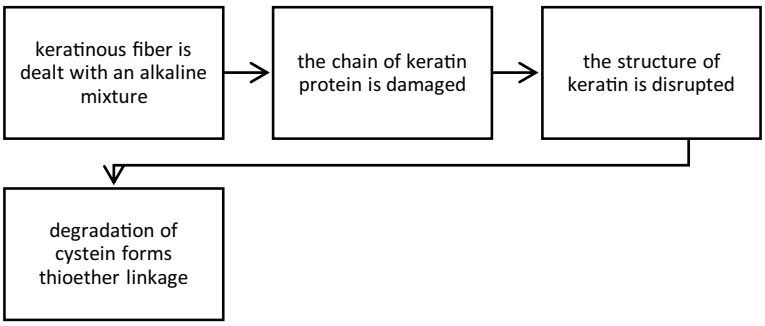

Fig. 1 Chemical procedure of keratin extraction (Rouse and Dyke 2010)

The dropping agents are—chemicals which is containing thiol (thioglycolic acid and also thioglycolate salts) and sulphite-o-lysis agents (like sodium sulphite and sodium bisulphite and sodium meta-bisulphite) and also 2-mercaptobisulphite (Aluigi et al. 2008). To enhance the extractability of keratin, plummeting agents are regularly used with denaturing agents and surfactants (Shavandi et al. 2017).

3.2 Keratin Extraction Using Sodium Meta-Bisulphite

Ayutthaya investigated keratin extraction from feathers of chicken by means of concentrations of the sodium meta-bisulphite (Ayutthaya et al. 2015). According to the German centralized stream Management Act, sodium meta-bisulphite poses to some extent risk in duty be neutralized before discharging, like treating using sodium hypochlorite solution (Khumalo et al. 2019).

3.3 Keratin Extraction Using Sodium Bisulphite

In a research investigation, one gram of pre-treated feathers of chicken was deep in 25 ml of aqueous suspension of 0.5 M sodium bisulphite, 8 M urea and 0.08 M SDS. Sodium bisulphite is non-combustible but it is harmful if swallowed, liberates noxious gases once it reacts with acids, endangers aquatic life; so, its disposal duty be illegal by stirring into sodium hypochlorite (Khumalo et al. 2019).

3.4 Extraction of Keratin Using Thioglycolic Acid

The other keratin extraction method is employed by thioglycolic acid. Pre-Gupta investigation, the comparison yield of keratin was 8.8% (Kakkar et al. 2014). Thioglycolic acid is noxious, and it causes severe skin burn and also eye damage and also inhalation. This substance should be stored in 2–8 °C for the reason that of its combustibility. Although Hatakeyama extend by 75% of yield by using the mixture of thioglycolic acid and sodium hydrated oxide for wheedle out keratin from sheep wool, this method is modifying for keratin extraction from chicken feathers, despite the fact that permitted to dissolving time of 16 h for a clarification pH consequence of 13 (Hatakeyama et al. 2009).

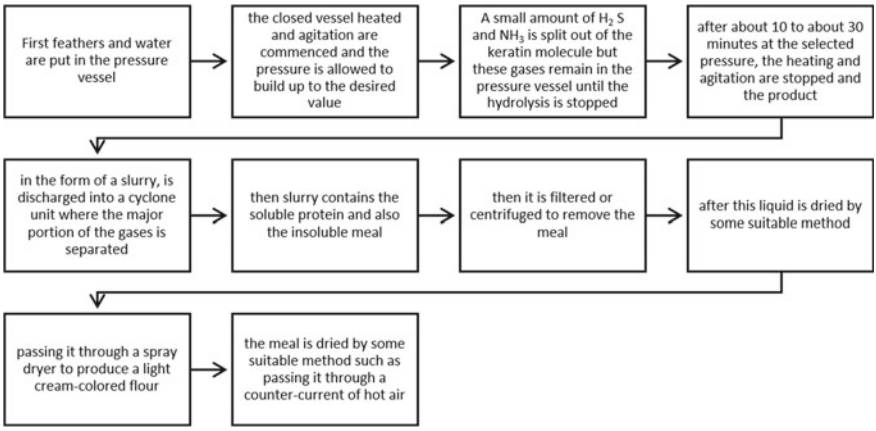

Fig. 2 Procedure of extraction of water-soluble and edible keratin protein from chicken feather (Kadri et al. 1976)

3.5 Extraction of Keratin by Using Imidazole Ionic Liquids

According to Ji investigation, the description showed that maximum yield of 75.1% by means of [Bmim] Cl ionic liquid under extraction time of hour at 90 °C (Ji et al. 2014). Imidazole ionic liquids are toxic. They set off skin irritation, acute discernment irritation and respiratory irritation (Khumalo et al. 2019). The liquid may be perilous if a big shot consumed expected to its moderate toxicity point (Hodge and Sterner 1949).

4 Digestibility of Isolated Pool and Limitation

In a research, we found the method to prepare a water-soluble and edible protein derived from keratin from sources of keratin like hair, fur, feather, wool, hooves, horns, claws, shells, nails and keratinous resources such as meals organized from them. Past solutions of proteins are prepared from such sources that the protein has usually been so degraded or contaminated that it has been unsatisfactory for use as a food and for many other uses (Kadri et al. 1976) (Fig. 2).

5 Application of the Isolated Protein as Food Supplement

The water-soluble keratinaceous protein prepared by the S. H. Kadri's method of this research is useful as a foodstuff either by itself or an additive in other foodstuffs including cereal and soybean flour, meats, animal feed, candy, soft and fruit

drinks. The nutritive value of foods for human consumption is enhanced by the addition to of the soluble protein which contains all of the essential amino acids like tyrosine, histidine, aspartic acid, methionine, valine, threonine, proline, cysteine, glycine, isoleucine, serine, glutamic acid, arginine, leucine, phenylalanine, lysine, tryptophan and alanine. The foodstuff provided by this report is especially useful as it is essentially free of water-insoluble protein which contained in keratinous meals and is substantially completely digestible by the pepsin within the alimentary canal of humans and animals (Kadri et al. 1976). Keratins though find applications in food, pharmaceutical, cosmetic and fertilizer industry, considerable amount of these products is wasted repeatedly. Acid, alkali or enzymes hydrolyze keratin and hydrolysates have number of applications (Gousterova et al. 2005; Grazziotin et al. 2006). Cosmetics based on keratin preparations have been reported for the treatment of human hair and skin (Kim et al. 1990). Isolation of keratins from above-stated methods yields a digestible raw protein product with potentially significant nutritional value. The naturally high levels of the amino acid cysteine in keratin suggest potential for dietary enhancement of the biological thiols' taurine and glutathione, which have diverse and important roles in health including potent antioxidant activity. Furthermore, keratins are a source of mixed amino acids which may have broad application as a protein supplement (Stipanuk et al. 2006; Silva et al. 2010). Stuart Houltham et al. has reviled in his study that daily consumption of keratin at doses above one gram and up to a significant proportion of daily protein requirement shows that the keratin supplements consumed up to 40 g per day for 5 days did not cause adverse gastrointestinal or other acute onset illness and is therefore safe for general consumption (Houltham et al. 2014).

6 Application of Keratin Protein in Market

In Indian market, there are many keratin supplements for hair that are available in many ways like hair oil, shampoo, conditioner and also protein powder, gums. After extracting keratin protein from non-conventional source, we get two kinds of keratin proteins. Some extraction method gives us edible keratin protein, and some gives us not soluble keratin protein. Those not soluble keratin proteins are used in hair product and hair treatment industry, and those edible keratin proteins are used in food industry (like protein powder and gums). Non-soluble keratin protein which we get from extraction and people cannot eat is useful which we can use in cosmetic industry for caring people's hair. Near there are a number of brands of the keratin mane treatment, entirely with about a parallel elemental substance structure. Hair cleansing, shape the modulation of hair is one of the physical highlights simpler to adjust. Haircare engineering has full-grown gift matter to devote radiance and adjustment a few mane attributes. Beard purifying substance was remembered for this plot in flimsy of the truth that, initially, they are broadly utilized and they weight mostly the highlights of beard makeup plane (perfection, sparkle, combability and hydrophobicity), and furthermore, they are as well utilized in the carrying out of locks

mould blend adjustments to get back moustache properties (pI, hydrophobicity other than the string exterior highlights).

7 Conclusion

Normally, human cannot digest keratin protein. So, in this modern world, with unhealthy food hobbies, people need supplementary keratin food products to control their hair fall as we all know keratin is good for hair. There are many methods by which keratin protein can be extracted from non-conventional source but maximum method's output is toxic, and also human cannot process it. In hydrolysis method, the extracted keratin protein is water-soluble, and human can easily digest this protein by their enzymes such as pepsin. This method's outcome product is cream coloured powder. So, we can use this in any kind of food product such as flour, candy, gum, soft drink and also in cultured meats. People can easily have keratin protein by consuming this food product in daily basis and also avoid their hair problems. Keratin has compact structural and robust mechanical properties which attract life science researchers for the proper understanding of physical, chemical and biological properties of keratin. Research on keratin is directed towards the advancement of numerous biomaterials having keratin for practice in application of biomedical field. For example, in recent days, hair damage (caused by UV radiation from sunlight, pollution, and nutrient-deficient food supplements) can be repaired by synthetic treatment of keratin. Additionally, keratinous materials have diverse hierarchal structures and functions that can be useful for development or architecture of new structure for the human benefit. In this modern generation, the amount of stress and technology is increasing at a very high pace. In this current scenario, food habits are getting affected the most, this in turn results in loss of proper nutrition. Due to lack of nutrition, necessary proteins are not available to the body such as keratin which is necessary for hair, skin, nails, etc. As lack of keratin occurs, it needs to be replenished in the body for that we need supplements of keratin. In this study, we have shown how to extract keratin from chicken feathers.

Acknowledgements We duly acknowledge Honourable Chancellor, Adamas University, Kolkata, India for providing us the infrastructure and facilities. This research work is financially supported by Seed fund for university sponsored research project (Ref No. AU/REG/2019-20/12/008), under Adamas University, India.

References

Aluigi A, Vineis C, Varesano A (2008) Structure and properties of keratin/peo blend nanofibres. Eur Polymer J 44(8):2465–2475

Ayutthaya SIN, Tanpichai S, Wootthikanokkhan J (2015) Keratin extracted from chicken feather waste: extraction, preparation, and structural characterization of the keratin and keratin/biopolymer films and electros puns. J Polym Environ 23(4):506–516

Basita A, Asghara F, Sadafb S, Waheed AM (2018) Health improvement of human hair reshaping using recombinant keratin K31. Biotechnol Rep (Amst) 20:00279–00288

Çam ST, Seyhan N (2012) Single-strand DNA breaks in human hair root cells exposed to mobile phone radiation. Int J Radiat Oncol Biol Phys 88(5):420–424

Gousterova A, Braikova D, Goshev I, Christov P, Tishinov K, Vasileva-Tonkova E (2005) Degradation of keratin and collagen containing wastes by newly isolated thermo-actinomycetes or by alkaline hydrolysis. Lett Appl Microbiol 40(5):335–340

Grazziotin A, Pimentel FA, De Jong EV, Brandelli A (2006) Nutritional improvement of feather protein by treatment with microbial keratinase. Anim Feed Sci Technol 126(1):135–144

Gupta A, Kamarudin NB, Kee CYG (2012) Extraction of keratin protein from chicken feather. J Chem Chem Eng 6(8):732–737

Hatakeyama R, Tomita Y, Takigami S (2009) Preparation of water-soluble wool keratin and its application for human hair. Trans Mater Res Soc Jpn 34(3):399–402

Hodge HC, Sterner JH (1949) Tabulation of toxicity classes. Am Ind Hygiene Assoc Quart 10(4):93–96

Houltham S, Starck C, Stannard S (2014) Two week keratin-based protein supplementation is comparable in gastrointestinal handling to a milk-based equivalent. J Hum Nutr Food Sci 2(4):1047–1054

Huang M, Wang W, Leung H, Chan CY, Liu WK (2012) Mercury levels in road dust and household TSP/PM2.5 related to concentrations in hair in Guangzhou, China. Ecotoxicol Environ Saf 81:27–35

Ji Y, Chen J, Lv J, Li Z, Xing L, Ding S (2014) Extraction of keratin with ionic liquids from poultry feather. Sep Purifi Tech 132:577–583

Kadri SH, Hanover P, Allen WM, Ky L, Pikel Ill OL (1976) Method for the preparation of water-soluble keratinaceous protein using saturated steam and water 75. United States Patent

Kakkar P, Madhan B, Shanmugam G (2014) Extraction and characterization of keratin from bovine hoof: A potential material for biomedical applications. Springer Plus 3:596

Khardenavis AA, Kapley A, Purohit HJ (2009) Processing of poultry feathers by alkaline keratin hydrolysing enzyme from Serratia sp. Hpc 1383. Waste Manag 29(4):1409–1415

Khumalo M, Tesfaye T, Sithole B (2019) Possible beneficiation of waste chicken feathers via conversion into biomedical applications. Int J Chem Sci 17(1):304–314

Kim WM, Kendahl W, Sherman L (1990) Protein additives for hair treatment composition. U.S. Patent 4,906,460

Langer S, Modanova J, Arrhenius K, Ljungstrom E, Ekberg L (2008) Ultrafine particles produced by ozone/limonene reactions in indoor air underlow/closed ventilation conditions. Atmos Environ 42:4149–4159

Li R, Wang D (2013) Preparation of regenerated wool keratin films from wool keratin-ionic liquid solutions. J Appl Polym Sci 127(4):2648–2653

McGovern V (2000) Recycling poultry feathers: more bang for the cluck. Environ Health Perspect 108(8):A366–A369

Qu CS, Ma ZW, Yang J, Liu Y, Bi J (2012) Human exposure pathways of heavy metals in a lead-zinc mining area, Jiangsu Province, China. PLoS ONE 7(11):e46793

Rajput R (2015) Understanding hair loss due to air pollution and the approach to management. Hair Transplant 5(1):1–7

Rouse JG, Dyke ME (2010) A review of keratin-based biomaterials for biomedical applications. Materials (basel) 3(2):999–1014

Shavandi A, Silva TH, Bekhit AA (2017) Keratin: dissolution, extraction and biomedical application. Biomater Sci 5(9):1699–1735

Silva LA, Silveira PC, Ronsani MM, Souza PS, Scheffer D, Vieira LC, Benetti M, De Souza CT, Pinho RA (2010) Taurine supplementation decreases oxidative stress in skeletal muscle after eccentric exercise. Cell Biochem Funct 29(1):43–49

Sinkiewicz I, Sliwinska A, Staroszczyk H (2017) Alternative methods of preparation of soluble keratin from chicken feathers. Waste Biomass Valorization 8(4):1043–1048

Stiborova H, Branska B, Vesela T (2016) Transformation of raw feather waste into digestible peptides and amino acids. J Chem Technol Biotechnol 91(6):1629–1637

Stipanuk MH, Dominy JE Jr, Lee JI, Coloso RM (2006) Mammalian cysteine metabolism: new insights into regulation of cysteine metabolism. J Nutr 136(6):1652S–1659S

Swetlana N, Jain P (2010) Feather degradation by strains of bacillus isolated from decomposing feathers. Braz J Microbiol 41(1):196–200

Tesfaye T, Sithole B, Ramjugernath D (2017) Valorisation of chicken feathers: Recycling and recovery routes. In: Proceedings, Sardinia. Clean Technol Environ Policy 19:2363–2378

Tsuda Y, Nomura Y (2014) Properties of alkaline-hydrolyzed waterfowl feather keratin. Anim Sci J 85(2):180–185

Veerabadran V, Balasundari SN, Devi DM (2012) Optimization and production of proteinaceous chicken feather fertilizer by proteolytic activity of bacillus sp. Mptk6. Indian J Innovations Dev 1(3):193–198

Wang S, Ang HM, Tade MO (2007) Volatile organic compounds in indoor environment and photocatalytic oxidation: state of the art. Environ Int 33(5):694–705