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Sustainable Paper – A Challenge for Preservation?

Abstract: Due to ecological and economic constraints the use and distribution of sustainably produced papers is increasing, which has an impact on the collections of cultural heritage institutions and their preservation strategies. In addition to alternatively produced papers a wide variety of recycled paper products are part of these collections. Preservation must therefore bring more attention to collecting data on the degradation of such heterogeneous media works¹ in order to be able to plan, implement and establish strategies and measures for the future. What this means in concrete terms will be shown using the example of the preservation data collection from the preservation department at the German National Library (DNB).

1 Introduction

The German National Library is located in Leipzig and Frankfurt am Main and is the biggest library in Germany.² The collection mandate of the German National Library includes all publications in written, visual and audio form published in Germany, in the German language, as a translation from the German language or about Germany since 1913.³

These include the printed works compiled or published between 1933 and 1945 by German-speaking emigrants which are collected in the German Exile Archive 1933–1945.⁴ The German National Library holds not only modern media works but also older originals: The German Museum of Books and Writing holds e. g. the world's biggest watermark collection and the Klemm-Collection with very valuable incunables. Today the German National Library's collection encompasses '43.6 million books, newspapers, journals, musical scores and publications, maps and archival materials in both physical and digital formats'.⁵

1 Media works: this term is used for all items in the German National Library, e. g. books, newspapers, maps etc.

2 Deutsche Nationalbibliothek, *Über die Sammlungen*.

3 Deutsche Nationalbibliothek, *Sammlungsauftrag*.

4 Deutsche Nationalbibliothek, *Sammlungsauftrag*.

5 Deutsche Nationalbibliothek, *Über die Sammlungen*.

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In the law regarding the German National Library, in paragraph 2, article 1, it is stated that the media works have to be collected in the original form and to be preserved permanently as national written cultural heritage: ‘Die Bibliothek hat die Aufgabe, [...] im Original zu sammeln, zu inventarisieren, zu erschließen und bibliografisch zu verzeichnen, auf Dauer zu sichern [...]’.⁶

Like other comparable institutions the German National Library collects a great variety of different media works which are heterogeneous in their material composition. In terms of preservation all materials have to be checked for their composition and material type so that a preservation concept due to possible degradation mechanisms can be created. The focus of this article is on sustainably produced paper, its degradation and preservation.

On the German book market sustainably produced media works are gaining a new importance. At this point it must be emphasised that it is in no way the intention of this article to criticise sustainably produced media works, e. g. made from recycled materials, as such. In the interest of environmental protection and the conservation of resources the focus on sustainability in the book and paper production is an important contribution to saving our environment. Nevertheless, from a preservation perspective some aspects must be considered more strongly in the future. The sustainability aspect of the production of such paper itself (ecology, benefits, climate protection and economic efficiency) and its evaluation will not be the subject of this article.

2 Short Context of Sustainably Produced Paper

The collection of the German National Library holds a number of sustainably produced media works. But what exactly are sustainably produced media works? The author of this article defines these papers as those which are produced in such a way that all or part of the resources used can be added back to an economic cycle, and/or are produced in a way that saves raw materials. A lot of parameters such as separating ink or dyes and/or glues from paper and last but not least the fibre quality play a big role in that context. The terms ‘environmental paper’, ‘waste paper’ and ‘recycling paper’ are used for papers which are also often labelled with the attribute ‘sustainable’. In Germany there are many labels for such papers with

⁶ *Bundesgesetzblatt* 2006, Teil I, Nr. 29. Translation (Stephanie Preuss): ‘the library has the task [...] to collect the original, to take inventory, to open up an record bibliographically, to preserve permanently [...]’.

different compositions. What they all have in common is that they describe papers that are reused to a certain extent in economic cycles.

Recycling paper is largely used in economic cycles. It is made of waste paper like writing paper, newspaper and so on. The paper fibres are diluted in water and cleaned in several steps with dyes chemically removed (deinking).⁷ This chemical treatment damages the paper fibres because the fibre length is affected,⁸ with the fibre pulp bleached according to requirements.⁹ There are recycling papers which are not being deinked or bleached.¹⁰ The recycling process is limited in revision (about six cycles).¹¹ Because of the downcycling (reducing of fibre quality) fresh fibres have to be added to get a specific fibre quality.¹²

Paper production has been optimised and changed over time because paper is basically a consumable material. In the past people tried to save resources and developed paper recycling treatments.¹³ For instance in 1774 there were verified attempts in making recycling paper.¹⁴

The environmental protection movements in the 1970s in Germany laid the foundation for the establishment of recycling in general.¹⁵ The 1980s were characterised by topics such as ‘forest dieback’, ‘acid rain’ and other environmental issues¹⁶ while the topic of ‘waste separation’ also came into focus.¹⁷ Since then recycling paper has been part of everyday life.

3 Sustainably Produced Papers Today

In recent years there has been a renewed focus in the industry on sustainability in paper production. The reasons for this are manifold, such as the situation on the paper market worsening economically in recent years and the raw material shortage leading to a shortage in the paper market. Even in common newspapers there

7 Tschudin 2012, 174; Igepa 1998, 78.

8 Leitner 2022, 85.

9 Willemer 1997, 476.

10 Willemer 1997, 477.

11 Igepa 1998, 80.

12 Leitner 2022, 4.

13 Willemer 1997, 477.

14 Willemer 1997, 477.

15 Brumme 2016.

16 Brumme 2017.

17 Brumme 2017.

were articles about this issue.¹⁸ For recycling paper production there was less raw material available due to the pandemic because less paper was circulating¹⁹ while industry-specific factors in general play a role in that context.²⁰ It is understandable that for reasons of economic efficiency and sustainability paper producers and publishers focus on recycling paper and alternatives since the ecological aspect is also an important marketing aspect.

3.1 Paper Labels

There are many labels for recycling or environmental papers in Germany but it is not always easy to get an overview. In the following the main labels are shortly introduced.

3.1.1 Blue Angel

These papers are made of 100% wastepaper and are produced without chlorine, optical brighteners or halogenated bleaching agents.²¹ There are different wastepaper qualities available such as the Blue Angel label which obligates paper producers to use at least 65% of less quality wastepaper for certain product groups in order to guarantee that paper producers use all available wastepaper qualities.²² Up to 5% of other materials like plastics, metals and so on are allowed.²³

3.1.2 FSC Recycled

FSC stands for 'Forest Stewardship Council' and means working under specific sustainable principles to manage forests.²⁴ The FSC Recycled papers consists of 100% recycling fibres but there is no regulation on water or energy saving and the use of chemicals.²⁵

¹⁸ *Der Spiegel* 2021.

¹⁹ *Der Spiegel* 2021.

²⁰ *Der Spiegel* 2021.

²¹ Der Blaue Engel (s. a.).

²² Der Naturschutzbund (s. a.).

²³ Der Blaue Engel (s. a.).

²⁴ Der Naturschutzbund (s. a.); FSC (s. a.).

²⁵ Der Naturschutzbund (s. a.).

3.1.3 FSC Mix

The label FSC Mix describes papers which contain up to 70% recycling paper.²⁶ In contrast to that FSC 100% means that the paper fibres are from 100% FSC certified woods.²⁷ These papers contain no recycling papers.

3.1.4 ÖKOPA

‘ÖKOPapier’ is made of 100% wastepaper.²⁸ Instead of bleaching the paper is whitened by using natural substances such as caolin, crayon or starch.²⁹ It has to get certified by the Blue Angel.³⁰

3.1.5 EU Ecolabel

The EU Ecolabel is the European label for environmentally friendly products and services.³¹

For paper production there are limit values for energy consumption, water pollution and air emissions.³² The papers can be bleached but using elemental chlorine is forbidden.³³ The raw material has to be certified 50% FSC or PEFC³⁴ but using wastepaper is not obligatory.³⁵ Thus, it cannot be assumed that recycled paper is mandatorily used.

3.1.6 Cradle to Cradle Certification

The cradle to cradle or C2C process strives to have an economic cycle that is as holistic as possible in which all components of production can be returned to the cycle

²⁶ FSC (s. a.).

²⁷ FSC (s. a.).

²⁸ Vencermos GmbH (s. a.).

²⁹ Vencermos GmbH (s. a.).

³⁰ Vencermos GmbH (s. a.).

³¹ EU-Ecolabel (s. a.).

³² Der Naturschutzbund (s. a.).

³³ Der Naturschutzbund (s. a.).

³⁴ Der Naturschutzbund (s. a.).

³⁵ Der Naturschutzbund (s. a.).

completely.³⁶ Papers which undergo such a cycle are certified in a special certification process.³⁷ The use of specific chemicals which can be dangerous or toxic for health and/or environment is subject to regulations in the certification process,³⁸ in addition, there are definitions for how compostable the materials used are.³⁹

3.1.7 PEFC: Programme for the Endorsement of Forest Certification Schemes⁴⁰

PEFC is an international certification system for the forest industry and forest owners.⁴¹

The PEFC label classifies sustainable wood and wooden products;⁴² in the case of paper the label is limited to the origin of the fibers.⁴³ Papers with the label 'PEFC recycelt' contain at least 70% wastepaper.⁴⁴

3.1.8 Grasspaper and Other Alternatives

In the book market but also in packaging in the food industry there are more and more alternative components in the paper that are intended to contribute to sustainability. On some tea-packages e. g. you can find the information that it is made of grass paper. Grass is already used as a raw material for paper production, currently mainly in the packaging sector,⁴⁵ but there are also experiments with fibres made of fruits.⁴⁶ 'Stonepaper' is made of up to 80% limestone and up to 20% bio-plastic (HDPE: High Density Polyethylene).⁴⁷ These beginnings in experimenting show that there is an intensive search for alternatives; it will become clear in the next few years whether these alternatives will be able to assert themselves or not.

³⁶ Braungart 2022.

³⁷ Cradle to Cradle Products Innovation Institute 2023a.

³⁸ Cradle to Cradle Products Innovation Institute 2023b.

³⁹ Cradle to Cradle Products Innovation Institute 2023c.

⁴⁰ PEFC a (s. a.).

⁴¹ PEFC a (s. a.).

⁴² PEFC a (s. a.).

⁴³ Der Naturschutzbund (s. a.).

⁴⁴ PEFC b (s. a.).

⁴⁵ Hanecke 2019.

⁴⁶ Nordig 2020.

⁴⁷ Leitner 2022, 250–251; Stone Paper Products GmbH 2023.

3.1.9 Rewritable Paper

There is research on papers which can be rewritten. Chinese researchers developed a paper in 2018 with a polymer layer that can be printed with a metal-based salt solution.⁴⁸ The paper and its components are supposed to be non-toxic and environmentally friendly as well as reusable up to eight times.⁴⁹ In 2007, a Japanese company experimented with a plastic paper made of PET which can be reprinted up to 500 times.⁵⁰

4 Challenges in Preservation Especially with Sustainably Produced Papers

4.1 Paper Degradation

Part of the German National Library's collection holds papers which are not of archival quality according to today's standards. These are not exclusively sustainably produced papers but papers that have poor aging properties due to lower production quality. The degrading mechanisms are complex and are therefore only described in general.

In industrial paper production from around 1850 onwards chemicals were used that can permanently damage paper.⁵¹ These are acidic substances that were primarily used for sizing;⁵² the acids destroy the nature of the cellulose chains that make the paper flexible and resistant.⁵³ Therefore the degree of polymerisation is a key factor for paper stability.⁵⁴ In addition, wood pulp (lignin-containing fibers) was used as raw material for paper production,⁵⁵ so that the fibres were shorter due to the milling process.⁵⁶ The acids accelerate the aging of the cellulose (hydrolysis)⁵⁷ while the air pollutants and degradation processes in cellulose can produce further

⁴⁸ Office Roxx 2018.

⁴⁹ Office Roxx 2018.

⁵⁰ Herbst 2007.

⁵¹ Bestandserhaltungsausschuss 2019, 3.

⁵² Bestandserhaltungsausschuss 2019, 3.

⁵³ Altenhöner et al. 2012, 9.

⁵⁴ Allscher and Haberditzel 2016, 79–81.

⁵⁵ Bestandserhaltungsausschuss 2019, 3.

⁵⁶ DIN 32701 2021.

⁵⁷ DIN 32701 2021.

acids.⁵⁸ This combination and other factors make these papers degrade faster than for example a medieval rag paper, although the influence of the lignin has not yet been adequately clarified;⁵⁹ as a consequence these papers become brittle and yellow. The acidic sizing is considered one of the main reasons for paper degradation in that context while reaction products from bleaching processes can have a corresponding after-effect.⁶⁰ This poses a big challenge for preservation because a lot of these media works are barely usable when severely degraded. Pages cannot be turned, they just break or tear quickly (Figure 1).

Since 1965 papers with a neutral pH – at least in the Federal Republic of Germany – have become more and more popular in paper production.⁶¹ In the 1990s the raised demands of the Frankfurter Declaration from 14 February 1990⁶² were implemented so that many publishers, paper producers and bookstores gradually began to focus on printing books on archival and acid-free paper in order to preserve the written cultural heritage.⁶³

As an international standard the DIN EN ISO 9706:2010-02⁶⁴ was created which defines the characteristics of permanent archival paper. For cardboard and thick cellulose materials in archival quality DIN ISO 16245:2012-05⁶⁵ was defined. In Germany more and more media works were produced with DIN ISO 9706 paper.

Due to their manufacturing process, sustainably produced papers are likely subject to the above degradation mechanisms depending on fiber quality and composition. In addition to the fiber quality as well as the acid problem there is also the fact that foreign substances can also be present.⁶⁶ Furthermore, depending on the source, imported waste papers do not always fulfil quality standards of the German paper industry;⁶⁷ even though the processes for producing recycled papers have improved and continue to improve over the years, an uncertainty factor remains regarding their degradation.⁶⁸ Therefore sustainably produced papers have to be considered in preservation strategies because even ‘...with common administrative

⁵⁸ DIN 32701 2021.

⁵⁹ Bestandserhaltungsausschuss 2019, 3.

⁶⁰ Bestandserhaltungsausschuss 2019, 3.

⁶¹ Bestandserhaltungsausschuss 2019, 5.

⁶² Neß 1999, 501–502, quoted from: Schmidt 2012, 26.

⁶³ Schmidt 2012, 26.

⁶⁴ DIN EN ISO 9706:2010-02, 2021.

⁶⁵ DIN ISO 16245:2012-05, 2021.

⁶⁶ Anders 1997, 478.

⁶⁷ Leitner 2022, 91.

⁶⁸ Anders 1997, 478.



Fig. 1: Acidic Paper. Image: Stephan Jockel, German National Library

and book-printing practices it is assumed to be a continuing problem...'.⁶⁹ Even if some recycling papers claim to be ageing resistant, they do not fulfil the criteria for papers with archival quality according to ISO 9706,⁷⁰ which also applies to papers produced according to ISO 20494.⁷¹ To clarify this the Conference of the Heads of the Federal and State Archive Administrations (KLA) and the Federal Conference of Municipal Archives at the German Association of Cities and Towns (BKK) have given

⁶⁹ Bestandserhaltungsausschuss 2019, 3. Translation: Stephanie Preuss.

⁷⁰ Archive im Rheinland 2021.

⁷¹ Archive im Rheinland 2021.

corresponding statements in 2015 and 2019 on that matter.⁷² These statements were directed primarily to the public administration.

In addition to acid-induced degradation papers also degrade under alkaline environments,⁷³ however, these degradation mechanisms are not completely researched yet.⁷⁴

A small digression should also be made about papers and books containing plastics. Depending on the material components plastics can get brittle, sticky or yellow⁷⁵ and the information can stick to the next page if getting in contact with sticky plastic. Coated papers can break, redeem or powder off depending on the coating's components. How alternative produced papers react in the material composite with regard to their degradation properties still needs to be further researched.

4.2 Preservation Strategies for Sustainably Produced Media Works

For acidic books and archival records there is a preservation treatment used globally by many institutions: mass deacidification.⁷⁶ The acidic components in the paper are neutralised and an alkaline reserve is placed in the paper structure to neutralize future arising acids.⁷⁷

In the German National Library about 2.4 million media works have been deacidified since 1994. Degradation processes due to acidic components can slow down under optimal storage conditions after mass deacidification.⁷⁸ Additionally, cold storage can contribute to slowing down degradation processes.⁷⁹ It depends on the collection and its condition which treatment or preventive measurements are carried out, either in isolation or in combination to preserve collections on a long term scale. In addition, economic and ecologic aspects have to be taken into account; to find the best strategy it is important to collect data on different aspects of preservation: e. g. data on storage, collection condition and treatments.

⁷² Bundeskonferenz der Kommunalarchive 2019.

⁷³ Ahn et al. 2013, 1998.

⁷⁴ Ahn et al. 2013, 1998.

⁷⁵ For further information on the degradation of plastics, see Ehrenstein 2007a; Ehrenstein 2007b.

⁷⁶ Allscher and Haberditzel 2016, 79–81.

⁷⁷ DIN 32701 2021.

⁷⁸ DIN 32701 2021.

⁷⁹ Michalski 2002, 66–72.

Deacidified media works have to be checked regularly for their acidity. If the alkaline reserve is too low, the paper gets increasingly acidic and degradation processes become faster.⁸⁰ After deacidification papers degrade differently,⁸¹ primarily depending on the paper characteristics including the ‘initial acid value’.⁸² Therefore, attention must be paid to these issues. It has to be said that by current research applying mass deacidification early on acidic books is effective.⁸³ Because many factors influence paper degradation it is reasonable to regularly check the surface-pH-value on deacidified books; on originals only non-destructive investigation can be done such as surface-pH-measuring. Ideally test papers should also be taken into account on these matters in order to do destructive tests which cannot be done on originals. However, to measure an effect, these must be statistically valid.

The German National Library has carried out surface-pH-measurements with a pH sensor since 2014 in a large scale sampling on deacidified media works. Its aim is to repeat the measurements about all five years in order to detect any changes.⁸⁴ All surface-pH-measurements with a pH sensor, regardless of the target, are carried out according to the instructions of the KUR project after Ahn et al.,⁸⁵ thus, the results remain comparable despite all uncertainty. After 2014 the first random sampling for deacidified stocks was started while the second sampling only started 2020/2021. Due to the pandemic not all measurings are finished so data is only available for the deacidification years from 1994 to 2005; the random sample includes more than 6,000 measurements with a confidence interval of 95%. Since the single measurement has only limited significance because it is associated with many uncertainties the sample is particularly large in order to be able to determine a ‘tendency’. Of course there are also test papers from each deacidification year which can be used for destructive measurements but they do not fully represent the originals in their natural ageing properties. In this context the approach remains a compromise – but still these measurements are very valuable as they enable long-term quality assurance and thus incidentally generate data for research.

Regarding the data it should be noted that the deacidified media works date from the years 1930 to 1991. They were deacidified with different deacidification methods and are stored under passive climate conditions but unfortunately a precise breakdown by deacidification method and year of publication is beyond the scope of this article. The media works are mainly monographs and series sig-

⁸⁰ Allscher and Haberditzel 2016, 79–81.

⁸¹ Ahn et al. 2012, 51–52.

⁸² Ahn et al. 2012, 51–52.

⁸³ Bestandserhaltungsausschuss 2019, 4.

⁸⁴ Ahn et al. 2012, 70.

⁸⁵ Ahn et al. 2012, 79–81.

natures. Figure 2 shows the results of the measurements from 2014 and 2021, comparing the deacidification years 1994 to 2005. It becomes clear that, excluding the deacidification years 2004 and 2005, the majority of the books show a surface-pH higher than 6.5 in 80% or more. A pH 7 is reached in over 70% or more except for the deacidification years in 2001, 2004 and 2005. Especially in the deacidification year 1994, the values decrease compared to the first measurement and it can be assumed that the alkaline reserve was depleted in this deacidification which occurred furthest back in time; this is also to be seen in the deacidification years in 2001, 2004 and 2005. These media works were very acidic before deacidification treatment and were also not stored under optimal conditions whereas the other media works were stored constantly under stable climate conditions but not cold storage. The applied deacidification method could only imply little alkaline reserve into the media works deacidified in 2001, 2004 and 2005. This example already shows the influence between the initial situation of the object condition, storage conditions and the implementation of the alkaline reserve. The measurements which require personnel resources are valuable in order to measure the sustainability of the treatment; this ensures the ability to intervene at an early stage if necessary. The storage conditions have been optimised for these media works today. Summarising the results, it can be stated that the mass deacidification treatment is effective since the results show an alkaline surface-pH range in average.

In the German National Library severely degraded media works are digitised by a specific course of business because deacidification is either not possible or

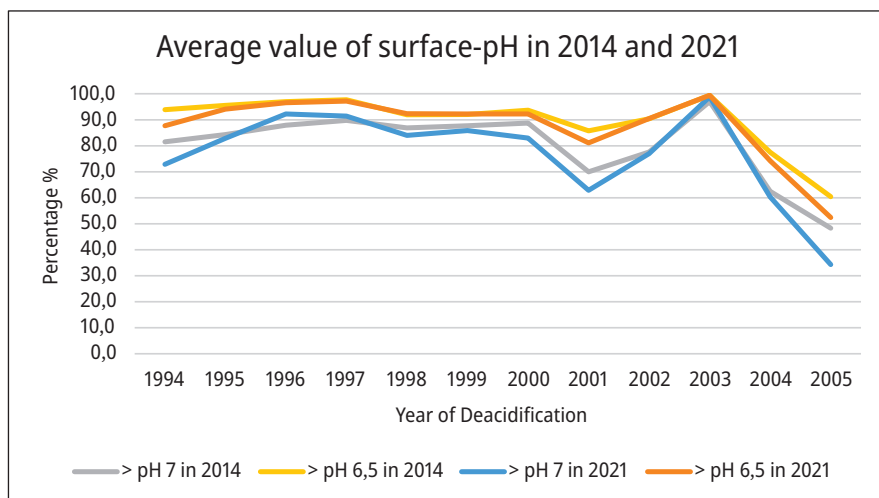


Fig. 2: Average value surface-pH in 2014 and 2021. Image: German National Library

uneconomical in relation to its benefits. These media works are boxed after digitisation and excluded from use; internally they are called ‘mummies’. It must be said, however, that not all papers from that period exhibit this problem since higher-quality papers continued to be produced and used for higher-value publications.

For media works which are not acidic in the first place – many modern papers do have an alkaline reserve even though they are not complying to the DIN ISO 9706 – a regular monitoring concerning their condition (visual examination regarding individual damage categories + material composition + surface-pH-measurement + storage conditions) is reasonable. Data collection requires appropriate resources but is essential from a preservation perspective in order to undertake meaningful action planning and to assess other groups of holdings of the same material composition.

In the case of brittle or glued plastics on or in a book there is, according to current research, little economically suitable conservation treatment to preserve them. In this case at least digitising the information, if technically possible, should be done so that further loss of information can be avoided. Another strategy can be copying it onto an archival paper medium. The same applies to certain coated papers.

It becomes apparent that the data collection for quality assurance and for monitoring the effect of treatments play an enormous role in preservation.

4.3 Collecting Data as an Important Strategy and Resource in Future Preservation

At present there is still not enough data on several preservation issues to make it possible for them to be used for research purposes and strategic decision-making. This is partly because on the one hand there are still not enough standards on how to collect such data and how to make it visible and available. On the other hand while condition surveys etc. are becoming more established data on long-term effects of measures are not yet sufficiently available. Such data can provide valuable information on how certain types of media degrade after a conservation treatment such as mass deacidification; in particular, data on the natural aging of media works are naturally scarce, however, if these are collected on a regular basis this could represent valuable information for future generations that can be used for research and not least for strategic conservation. This is especially true for objects made of alternative composite materials for which there is as of yet little data. Data on mass deacidification, re-acidification, climate data, regarding different storage concepts and of media works themselves (material composition, condition, state of aging, etc.) can contribute to the ability of other institutions which can benefit

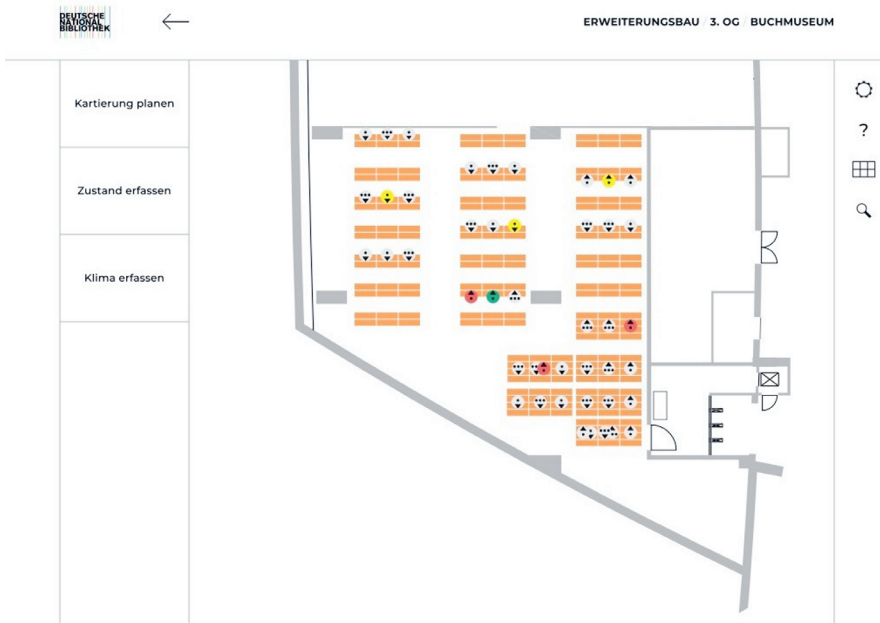


Fig. 3: App Bonpland for Condition Control German National Library, Design: CLMNZ/Clemens Hartmann. Image: German National Library

from this data as they may not have the resources or expertise to collect data themselves. Such an approach requires clear guidelines and unambiguous definitions of damage patterns, measures, description of storage conditions, etc. It initially consumes resources and is also highly complex but it is worthwhile in the long run to consider and plan a holistic cultural heritage conservation strategy regionally, nationally and ultimately globally. There are initial approaches where data collection has begun, e. g. in the form of queries of certain parameters in institutions on preservation issues as the basis for a concept development, e. g. for a state programme on preservation.⁸⁶

The German National Library has begun to collect certain preservation data on these issues. Because the collections are inhomogenous but also because storage conditions at both sites are different the data situation is complex and variant. Additionally, over the years different types of preservation treatments came into use. With a software company an app called Bonpland was developed for the German National Library in which maps of the storage rooms visualize objects' condition,

⁸⁶ See for state programmes on preservation Graf 2022, 25–38.

data on climate condition and other relevant storage and/or object data (Figure 3). On the one hand this provides an overall view of the condition of the media works and on the other hand it allows specific questions to be asked such as the acidity of certain media works. Overall it is important for such surveys to define clear categories that are also clearly comprehensible for other stakeholders; evaluation forms such as ‘good’ or ‘bad’ with regard to e. g. the conservation status are therefore not sufficient. Also, the possible bias which is always present in measurement data must be outlined as precisely as possible. In the app it is possible to measure quickly the condition of media works in stocks or in a segment with a statistically valid random sample with a confidence interval up to 95% (variable adjustable). The collected data is used for strategic preventive treatment planning in preservation which can be transferred to other data analysis programmes so that they can be used more widely in perspective.

4.3.1 Data on the Acidity of Paper in the German National Library

From 2000 up to 2020 the acidity of paper in monographs was checked during indexing the media works in the German National Library. A pH-pen was used and information about the paper composition/type in the imprint were checked. Using a pH-pen, however, is not an exact measurement method; the pen gives an indica-

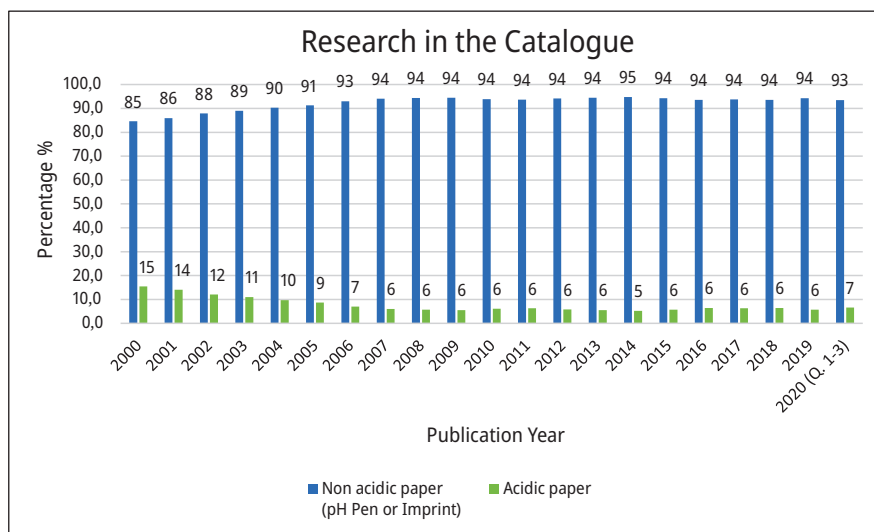


Fig. 4: Research in the DNB Catalogue System. Image: German National Library

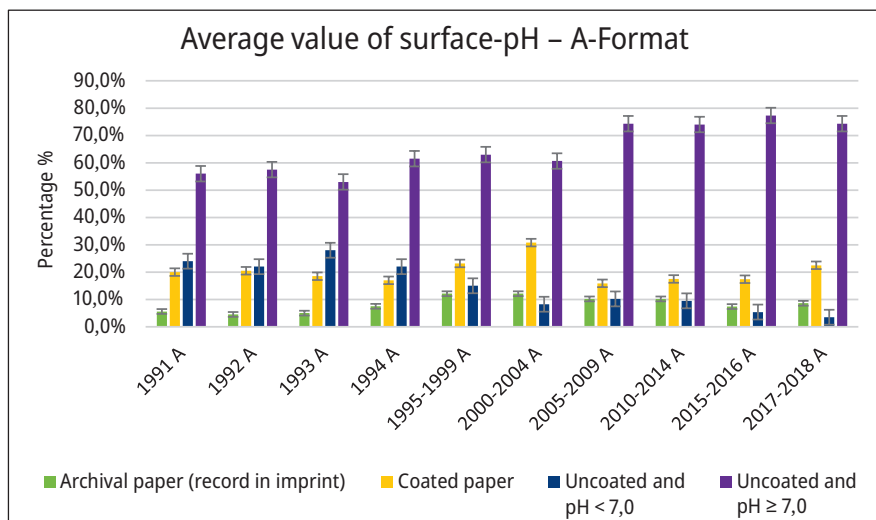


Fig. 5: A-Format – Average surface-pH. Image: German National Library

tion of the acidity since the coloration cannot always be clearly evaluated (e. g. if the paper already has a yellow tint). The results determined are therefore not to be regarded as absolute results and the data thus has a corresponding lack of precision. For this reason the data is no longer collected in this way, however, the available data provides an initial indication. Figure 4 shows that in the early 2000 15–10% acidic paper was detected while since 2007 the percentage nearly cuts in half when the year 2000 is taken as a starting point. The proportion of acidic paper remains stable from the year 2006. However, in 2020, these values were only determined in the first three quarters of the year.

Within the monographs the surface-pH was investigated with a pH-sensor per publication year before deacidification treatment (confidence interval 95%). It was also noted whether there was information in the imprint about the paper composition regarding to archival paper.

It was noted how much coated paper was found because these cannot be deacidified. The results in Figure 5 of the A-Format⁸⁷ show that more than 50% of the paper do have a surface-pH over 7. In the publication years since 2005 the number has even risen to over 70%. Coated paper is present up to 20% in the publication years 2000–2004 while in 2017–2018 it is a little higher. Since 1995 the value for archival paper increased but since publication year 2005 has been under 10% and declined

⁸⁷ Formats in the German National Library: A-Format Maximum 25 cm, B-Format Maximum 35 cm.

slightly on average. Uncoated paper with surface-pH lower than 7 can be found in the publication years in the early 1990s at slightly more than 20%. Since 1995 the number has been decreasing, since 2000 at less than 10% and 2017/2018 at less than 5%.

It looks slightly different in the B-Formats (Figure 6). Only since publication year 1994 has the number of papers with surface-pH over 7 been higher than 50%, with the average values increase since the publication year 2005 up to more than 70%. The results for coated paper have varied and been higher than 40% in the publication years 1991–1992 and 2000–2004 while being under 30% in the other publication years, while since 2010 they have been around 20%. In the years 1990–2009 less than 5% of archival paper seems to have been used. Only from 2010 have the average values increased while not exceeding 10%. With about 20%, the number of acidic paper in the publication years between 1991 and 1993 is specifically high while decreasing from 1994 to around 10%.

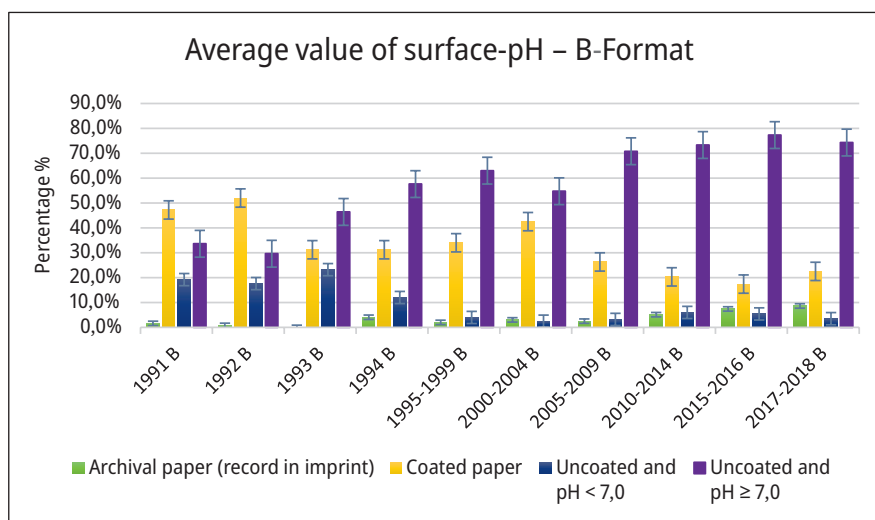


Fig. 6: B-Format – Average surface-pH. Image: German National Library

With regard to the definition ‘archival paper’ it must be stated restrictively that the description in the imprint cannot always be unambiguously assigned to DIN ISO 9706. However, the term ‘ageing-resistant’ or ‘archival paper’ is not always understood to mean the same thing; as already mentioned above some papers are designated as such that do not meet this requirement of DIN ISO 9706. Even if the majority of the measured values determined show a corresponding pH value of more than 7, this does not necessarily mean that these papers also have ‘archival quality’ since other parameters also contribute to this.

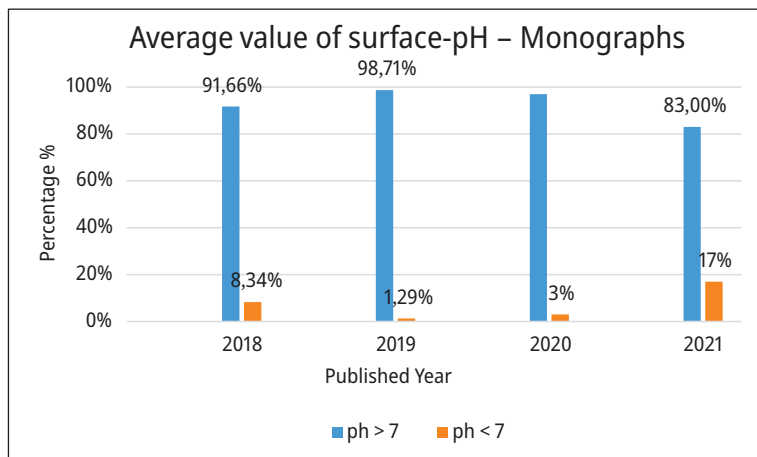


Fig. 7: Modern Monographs A-and B-Format – Average surface-pH. Image: German National Library

In another examination of monographs for the current years only surface-pH-measurements with a pH-sensor (confidence interval 95%) due to resource shortages were carried out. Figure 7 summarises the results for the publication years 2018–2021 for A- and B-Format; it shows that more than 83 up to approximately 98% of the monographs have a surface-pH higher than 7. It is interesting that in 2019 and 2020 a very small amount seems to be lower than pH 7 but in publication year 2018 about 8% of the papers show a surface-pH lower than 7. Nevertheless, in 2021 the number of papers below surface pH 7 nearly doubles in comparison to 2018; whether this is just an ‘outlier’ or whether it is a trend towards acidic paper will be shown in the future measurements for the following publication years.

The preservation department has also started to measure the surface-pH with a pH-sensor of current journals (Figure 8). The data for the publication years 2016–2018 is available, however, the measures are not completed yet since earlier publication years are checked as well. In 2016 4% of the journals show a surface-pH lower than 7 while in the publication years 2017–2018 the surface-pH lower than 7 is around 1%. It will be interesting to see whether the journals of the earlier publication years will show different results.

As already described, many factors determine the deterioration of papers starting from fiber components, chemical additives and other substances and so on. Therefore, their condition must be checked regularly in order to be able to react early and sustainably which applies in particular to papers whose surface-pH is slightly below 7. Despite all the uncertainties of the measurements – because these are not absolute values – these values show a tendency. Besides the surface-pH

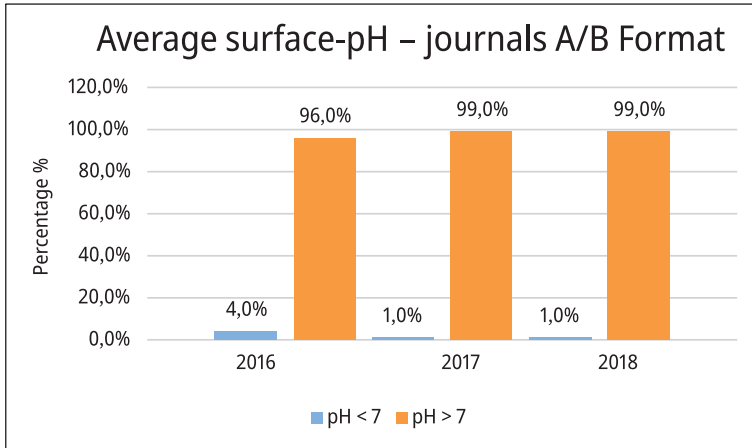


Figure 8: Average surface-pH – Journals A/B-Format. Image: German National Library

other condition parameters have to be checked as well such as yellowing, mechanical properties of the item and others. Last but not least the collection size must also be taken into account. The numbers of the publication years naturally fluctuate; even if only 20% of a publication year needs to be deacidified or treated in another way then for example 40,000 books have to be treated if 200,000 books are considered as the basic population. These investigations have not been completed but will be continued for the coming volumes while the entire periodical and music collection is also currently being examined. Accordingly, no values are yet available. A clearly heterogeneous picture may emerge here as in these collections there are very mixed paper qualities.

4.3.2 Data in Imprint About Paper Quality in the German National Library

In the German National Library data from the imprint of media works is collected in order to see whether the information on paper types is on focus and how the use of paper types will develop, with a current time period deliberately chosen in order to be able to read off developments in the modern holdings in particular. In contrast to the examination before the deacidification which only looked at the information on 'archive quality' all information is explicitly recorded here, also in order to include new developments such as 'grass paper', etc. The examination has started within the monographic collection with the data available for the publication years 2015–2018 in A-Format (Figures 9 to 12). The random sample was taken with a confidence interval of 95%.

It is obvious that in all publication years the number of not classified paper is highest, making up 70.6–83.6%. But at the same time it can be seen that it reduces due to a greater variety of paper types. Specifically, the FSC Mix papers are rising within the publication years starting from 10% proportion up to 20.1% in 2018 and it seems likely that the use of these papers are rising in the following publication years. All surveys show the presence of archival paper, rising from 0.2% to 7%, however, it is unclear whether this specifically refers to DIN ISO 9706. It is interesting that in the publication year 2015 DIN ISO 9706 papers are present up to 5.5%, but are reduced in 2016 to 1.3% and in 2017 to only 0.7%, while rising again in 2018 to 2.0%. The mention of sustainably produced papers in the imprint is not present in 2015 but is in the publication years 2016–2018 with only 0.2%. In particular, cradle to cradle papers are present in all publication years varying between 0.7% for 2015 and 0.2% for 2016 to 1.3% for 2017 and 0.7% for 2018. Recycling paper is mentioned in the publication years 2016–2018 with small percentages ranging from 0.5–1.5%, while Blue Angel paper can be identified for the publication years 2016–2018 ranging from 0.2–0.5%. FSC 100% paper can only be found in the years 2016–2018 with also a small percentage of 0.2–0.5%.

The following total numbers of media works are extrapolations based on the samples. Considering the number of signatures in the publication years it can be concluded that for 2015, with approximately 110,000 signatures, 11,000 media works consist of FSC Mix papers and approximately 91,300 media works are present without indication of the paper types. Only 5,500 media works are suitable for archiving in terms of paper quality according to DIN ISO 9706.

For the publication years 2016–2018 the number of signatures is about 100,000 media works per year.

If the recycled papers and the sustainably produced papers are added together for the publication year 2016 approximately 16,900 media works (total 16.9%) contain recycled paper/sustainably produced papers. For about 76,500 media works from 2016 the paper composition is not further specified. Only about 1,300 media works from 2016 have a paper quality according to DIN ISO 9706.

In the publication year 2017 about 74,600 signatures have no indication of paper types and about 16,700 monographs are on FSC Mix papers. Only 700 signatures from 2017 have DIN ISO 9706 papers indicated whereby approximately 7,000 media works from the publication year 2017 indicate paper in archive quality.

900 media works of 2018 have information on sustainably produced papers in the imprint. Some 70,600 media works would therefore have no indication of paper quality, while 20,000 media works consist of FSC Mix papers. Approximately 20,100 signatures in 2018 are papers according to DIN ISO 9706 whereby approximately 5,100 media works show at least an 'archive quality'.

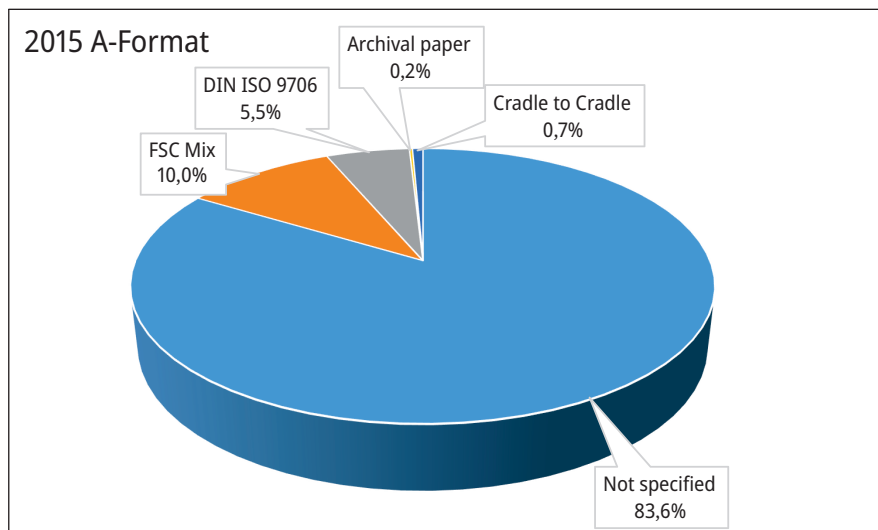


Fig. 9: Paper types in Imprint – 2015 A-Format. Image: German National Library

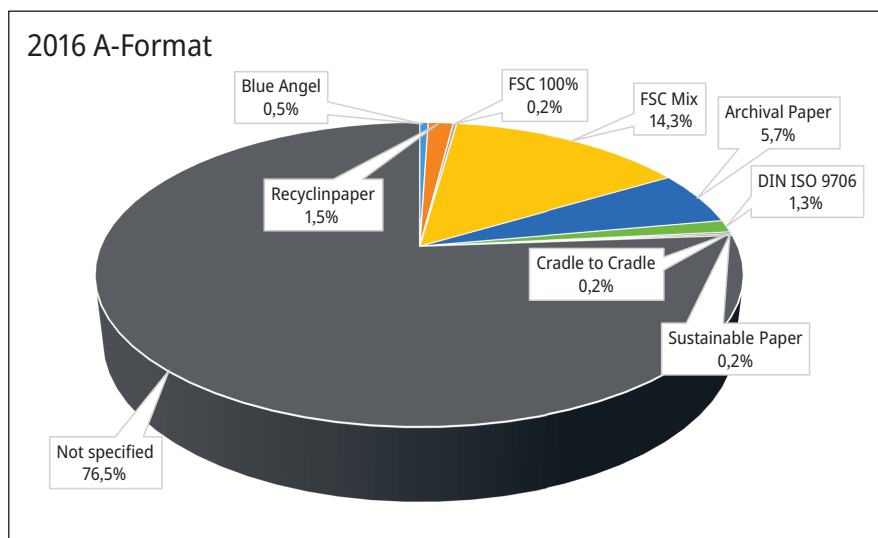


Fig. 10: Paper types in Imprint – 2016 A-Format. Image: German National Library

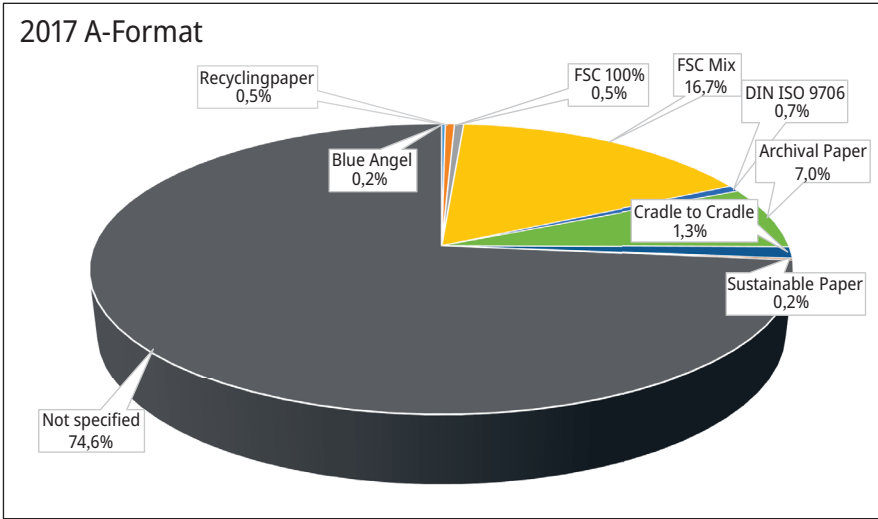


Fig. 11: Paper types in Imprint – 2017 A-Format. Image: German National Library

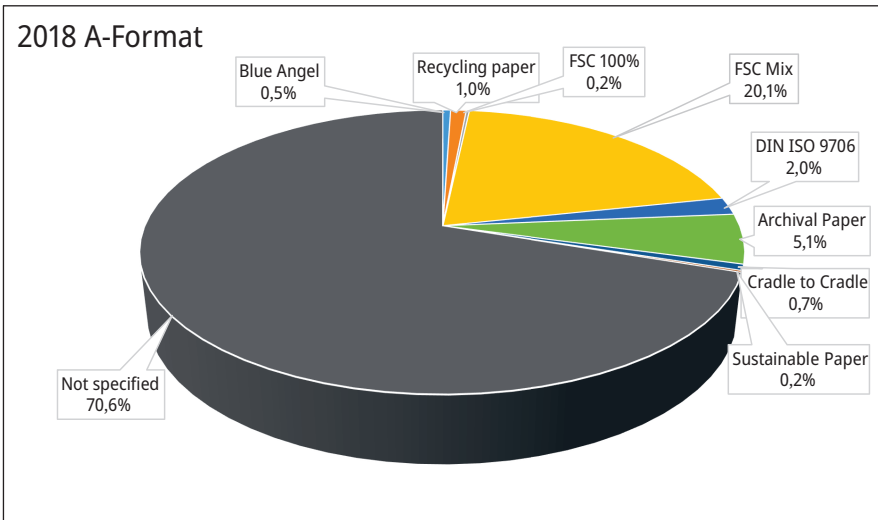


Fig. 12: Paper types in Imprint – 2018 A-Format. Image: German National Library

Figure 13 shows the average values from the publication years 2015–2018. It can be shown that not specified papers make up the largest share at 76.3%. Archival papers and papers in accordance with DIN ISO 9706 account for around 7%. Recycled papers, FSC 100% papers and Blue Angel papers account for an average total share of 10.3%, while FSC Mix papers show a value of 15.3%. Sustainably papers including cradle to cradle papers have an average share of just under 1%. The data implies that over the years more often paper compositions have been named in the imprint. Further surveys will have to show whether trends can be identified from this. Whether degradation processes due to acids or other components will take place must then be checked regularly and if there is a slight tendency towards acidification then it is possible to react at an early stage. All statements are related to the measurements referring to this article but it remains to be seen what the further results will be as the measurements have not yet been completed.

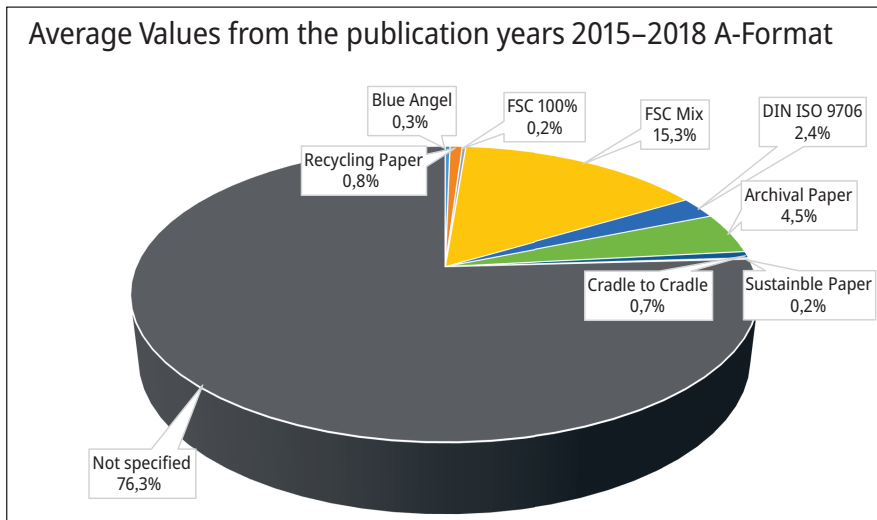


Fig. 13: Average values from the publication years 2015–2018. Image: German National Library

5 Conclusions

Paper qualities play a significant role in the preservation strategy of the German National Library. As sustainability aspects in particular are once more having a stronger role in the book and paper market the focus on this topic is increasing. According to the data currently collected FSC Mix papers are present in up to just

under a quarter of the modern monograph stock depending on the publication year. The still much larger part of the collection does not contain any labelling at all with regard to paper composition, neither in the direction of sustainably produced paper/recycled paper nor in the direction of 'archive paper' and 'papers according to DIN ISO 9706'; it would be great if there is a commitment to label the paper quality in each printed media work. According to the current economic situation it is to be expected that the production towards recycled papers or papers which contribute to sustainability aspects, whether as a mix or fully sustainably produced papers, will continue and increase. Therefore, monitoring the collections of the German National Library will be continued to set up appropriate measures at an early stage in terms of damage prevention and to obtain data for the natural aging of such papers. As the data of the surface-pH measurements shows, a large part of the papers used in books from recent publication years are no longer strongly acidified; nevertheless special attention must be paid to the collections since the paper qualities are different and the distribution seems to shift or change slowly in the publication years. This ensures the ability to react preventively such as in the case of early degradation. The data on deacidified books show that the mass deacidification is effective. Furthermore, alternative papers have to be checked regularly with regard to their degradation in order to create a database for research and for strategic action planning.

Overall, various aspects of economic efficiency, sustainability, preserving information, treatment planning and an optimal climate range must be combined in the best possible way to ensure the most long-term preservation effect. Increasingly, preservation means not only the implementation of certain conservation treatments of the collection but above all strategic decision-making and risk assessment considering sustainability aspects. In this context data collection is just as important as the measure itself. Only in this way can the handling of the enormous quantity of media works be taken into account.

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