**Methods**

**Grant number:** ES/T008121

**Sponsor:** UKRI

**Project title:** Water & Waste: Expanding safe water and waste management services access to off-grid urban populations in Africa

**Data set:** Testing of a novel, low cost method to identify plastic resins used for production of food and beverage packaging in Kisumu, Kenya, and Greater Accra, Ghana

**Version** 1, completed January 2024

## ****Objectives****

Preceding work led to the development of a simple method to identify plastic resins/polymers used for food and beverage packaging that employs simply- and readily-implemented observations (Shaw *et al.*,2022). The present study aimed to evaluate this method in terms identification outcomes, with regard to accuracy and consistency. On the basis of the observations made, this work sought to evaluate how well the identification methods perform, and how adjustments might be made when considering specific purpose and settings.

## ****Study design and materials****

The sequence of tests and observations intended to identify resins (Figure 1; Table 1) was carried out for a test set of plastic food and beverage packaging items as a means to evaluate whether the observations made and resultant identification outcomes were accurate and consistent. Types of packaging were for routine purchases of food and beverages commonly in household waste streams (including water) for consumption in the home.

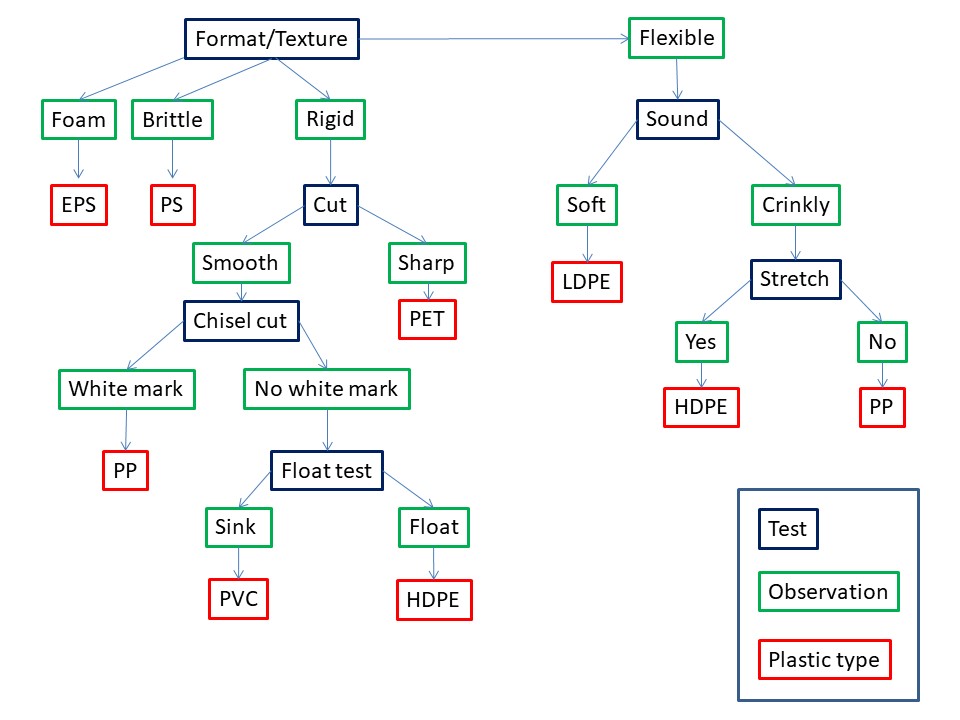


Figure 1 Observations and tests (*see* Table 1) to determine resin types of plastic packaging (Shaw *et al.*, 2022). PET: polyethylene terephthalate; PP: polypropylene; HDPE: high density polyethylene; LDPE: low density polyethylene; PVC: polyvinyl chloride; PS: polystyrene; EPS: expanded polystyrene.

Table 1. Tests and observations used in conjunction with the identification framework (Figure 1). Adapted from Shaw *et al.*, (2022). 1 all samples; 2 rigid samples only; 3 flexible samples only.

|  |  |
| --- | --- |
| **Test or observation** | **Notes and comments** |
| Format/Texture1 | Is the item self-supporting; not easily forced out of shape (rigid) or not self-supporting; easily re-shaped (flexible film or soft material)?  Is the item lightweight, soft to the touch and pliable?  Does the item break when bent with the hands? |
| Cut2 | Is the cut edge smooth or sharp to the touch when cut with a sharp knife? |
| Chisel cut2 | When cut with a sharp chisel, held at an angle of 30-45° to the surface of the item, does the cut edge appear white? |
| Float test2 | Do 1cm x 1cm pieces float or sink in a glass beaker of water when pushed under the water surface and without air bubbles adhering to the surface? |
| Sound3 | Does the packaging make a “soft, swishing” or a “crinkly” sound when rubbed together between the fingers and thumb? |
| Stretch3 | Does a strip of the packaging about 1cm wide and 10cm long stretch when held firmly between the hands and pulled? |

Plastic packaging samples from household waste were collected opportunistically by the researchers based in the UK. Samples included some bearing identification marks for which resins did not need to be determined by other means. Samples were intended to provide materials to test the identification approach as developed and thus comprised items of packaging differing in terms of format (“rigid” or “flexible”) and resins (PET, PP, HDPE and LDPE). Samples were all for food and beverage product packaging; these comprised samples of the three resins commonly used for rigid packaging (PET, HDPE and PP) and the two resins commonly used for flexible packaging (LDPE and PP). For samples without plastic type(s) indicated on the packaging, resin identification was made using an extended suite of physical attributes (Table 3) and/or further tests as appropriate (Katz, 1998).

Samples of packaging items were shared between research teams in Ghana and Kenya. Tests were conducted by four individuals in Ghana and five in Kenya. Samples were tested by either both teams or one alone. Individuals undertaking tests and observations had 1-15 years of experience in field data collection and related observations; most of the participants were educated to Bachelors or Masters degree level. Observations and tests were conducted in June 2022 in Kenya and July to September 2022 in Ghana, in classroom settings without specialist analytical equipment or facilities. Prior to undertaking tests and observations, all participants were provided with guidance and notes for the identification framework (Figure 1) and the observations and tests themselves (Table 1). Demonstration video films for tests and observations, using exemplars of known resins, were provided[[1]](#footnote-2). Participants conducted observations and tests individually and without sight of observations made by others within their team. Five different types of packaging were tested, comprising three resins for rigid items and two resins for flexible packaging; 36 to 81 individual and independent observations were made for each packaging type (Table 2).

Table 2. Tests and observations conducted on samples of plastic packaging to evaluate the accuracy and consistency of test and observations outcomes (*see* Table 1) and identification framework (*see* Figure 1).

|  |  |  |  |
| --- | --- | --- | --- |
| **Packaging format; resin** | **Number of packaging items evaluated** | | |
|  | **Ghana** | **Kenya** | **Total** |
| Rigid; PET | 36 | 45 | 81 |
| Rigid; HDPE | 20 | 20 | 40 |
| Flexible: LDPE | 32 | 40 | 72 |
| Rigid; PP | 12 | 20 | 32 |
| Flexible; PP | 16 | 20 | 36 |

## Data management, processing, quality control, linkage and anonymisation

*Data management:* All outcomes of observations and tests (Table 1) were uploaded onto MS *Excel* spreadsheets and collated. All data were anonymised prior to collation of data; individuals conducting observations and tests in Ghana were labelled G1-G4 and K1-K5 for Kenya. Samples of plastic packaging were each assigned a sample code (e.g., PP/F-01 for polypropylene/flexible/sample #1); samples evaluated were labelled using codes that did not indicate resin type.

*Quality control:* Quality control measures undertaken during and following data collection included the following:

* Entered variables were checked for consistency and accuracy; where errors were evident (e.g., typographical errors in text entries), corrections were made such that terminology was consistent.
* All data were checked for duplication of records by reference samples codes and observer codes; no duplicates were identified.

*Data structure, linkage & related data resources:*

Files are as follows:

Microsoft *Excel* spreadsheets: There are two separate files, one for flexible items of plastic packaging[[2]](#footnote-3) and one for rigid items[[3]](#footnote-4). Each record comprises outcomes of a series of observations and tests (Figure 1; Table 1) for an individual sample, and as recorded by individual observers. There are at least four and up to nine observations for each packaging item. Identification outcomes, as made on the basis of observations and tests (Table 1), and in relation to the identification framework (Figure 1) are indicated alongside each individual record, and classified as correct or incorrect by reference to the known or established resin.

*References:*

Katz, D.A. 1998. Identification of polymers. https://www.academia.edu/33686662/IDENTIFICATION\_OF\_POLYMERS?msclkid=3bb9b772b42011ec9bedcda8ecd2730a (accessed 30 March 2023).

Shaw, P.J., Okotto-Okotto, J., Okotto, L., Chen, Y., Wright, J.A., Dzodzomenyo, M. (2022). Identifying plastics used for food and beverage packaging: needs and challenges. Sixth Symposium on Urban Mining and Circular Economy, Capri, Italy, 18-20 May 2022.

1. https://waterandwaste.org/outputs/outputs-explained/low-cost-method-of-identifying-plastic-packaging/ [↑](#footnote-ref-2)
2. FlexiblePlasticPackagingIdentification.xlsx [↑](#footnote-ref-3)
3. RigidPlasticPackagingIdentification.xlsx [↑](#footnote-ref-4)