Industrial pollution and social deprivation: evidence and complexity in evaluating and responding to environmental inequality

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Abstract

The local impacts of industrial pollution can take many forms and, whilst uncertain in their scale, severity and distribution, are widely recognized. The question of who in society potentially experiences these impacts through living near to emission sources has been little explored, at least in the UK. This paper reports on a study carried out for the Environment Agency, which examined the distribution of sites coming within the Industrial Pollution Control (IPC) regime against patterns of deprivation. Our analysis provides evidence of a socially unequal distribution of IPC sites in England, with sites disproportionately located and clustered together in deprived areas and near to deprived populations. In discussing these results we emphasise the methodological limitations of this form of environmental justice analysis and the crucial differences between proximity, risk and impact. We also consider the distinction between inequality and injustice and the difficult policy questions which arise when evaluating evidence of environmental inequality, including potential grounds for policy intervention.

Introduction

Industrial pollution attracts both intense regulatory attention and, periodically, public anxiety and concern. Major industrial installations are a source of a diverse range of pollutants leading to potentially significant but disputed health impacts (Bhopal et al 1998, Pless-Mulloli et al 1998, Dunn and Kingham 1996). When set alongside other negative impacts such as noise, odour and, in some cases, stigmatization of both places and local people (Bush et al 2001, Powe and Willis 1998, Simmons and Walker 2004), industrial sites may become a significant burden on local communities. This burden often fails to be compensated by the economic benefits of local jobs and income, particularly as patterns of traditional association and dependency between companies and local communities have broken down (Irwin et al 1999).

Whilst the local burden of potential and experienced industrial pollution is widely recognized, the question of who in society is taking this burden has been less explored, at least in the UK. When we talk of impacts on the local public and community, what types of people and community are involved? Are there patterns in the socio-spatial distribution of industrial installations which mean that certain groups are more likely to experience negative impacts from such sites than others? If the pattern of distribution of industrial polluters is socially unequal, can this be characterized as a distribution that is also socially inequitable and unjust and in need of some form of policy intervention? Does such environmental inequality contribute to or exacerbate more established and proven concerns about health inequalities for deprived and social excluded communities?

Such questions of environmental equity and justice have been researched for some time in the US (Bryant 2003). Multiple empirical studies at different scales and with varying spatial coverage have examined the distribution of industrial and waste sites principally in relation to patterns of ethnicity. The US Environmental Protection Agency has also, over the last decade, developed and implemented policies that seek to incorporate environmental justice concerns into regulatory practice and processes of interaction with local communities (Eady 2003). In the UK, we are at a far earlier stage of analysis and development of policy. Environmental justice is emerging as new policy discourse in which the interrelationships between environmental and social justice are being broadly conceived (Agyeman and Evans 2004) and environmental researchers are increasingly turning their attention to questions of distribution, equity and justice (Lucas et al 2004). However, there are still major gaps in our understanding of the socio-spatial landscape of environmental benefits and burdens which both empirical and more theoretically-driven research need to address.

This paper reports on a study carried out for the Environment Agency for England and Wales, which, amongst a number of other analyses, examined the distribution of sites coming within the Industrial Pollution Control (IPC) regime against patterns of deprivation in England and Wales[1] (see Mitchell and Walker 2003 and Walker et al 2003 for a discussion of the overall research project). Our objective is not just to report on the empirical results of this work, but also to consider the methodological and conceptual issues which complicate the interpretation of the evidence produced and the policy implications and complexities that then emerged.

The social distribution of industrial pollution: existing research

Much of the environmental justice research in the US that has accumulated over the last 20 years, has focused on the locations of industrial and waste installations (Davidson 2003). The total body of research covers a wide range of scales of analysis (from local to national), environmental variables (some attempting to take account of different levels or toxicity of emissions as recorded in the Toxic Release Inventory) and social variables (largely ethnicity, but also class, income, age, population density) (Liu 2001). There has been much debate about the conclusions that can reasonably be inferred from this research, with a particular focus on allegations of discriminatory siting practices. Some observers have concluded that,

[1] Whist the research project separately analysed data for England and Wales, this paper considers only the results for England. However, the differences revealed between patterns of distribution for England and Wales are discussed in evaluating evidence and examining issues of scale in environmental equity analysis.

collectively, these US studies show that the location of polluting factories and waste facilities are biased towards areas with a higher proportion of black or hispanic populations, and to a lesser extent areas of lower social class (Szasz and Meuser 1997). However, others have pointed to the existence of contradictory results and the low quality of many of the higher profile pieces of equity research (Bowen 2002, Davidson 2003). Bowen and Wells (2002) are particularly critical describing a 'rhetoric-reality gap' in which the many claims for environmental injustice, including some which have significantly influenced national policy, have not been adequately supported by evidence from thorough, systematic research. Liu (2001) similarly argues from a US perspective that whilst there has been an improvement in the quality of research, there are still many methodological issues to be wrestled with and that consequently environmental justice analysis should be viewed as in a ‘pre-paradigm’ stage of development.

In the UK the range and depth of research examining the location of industrial pollution is far more limited than in the US. At the time of undertaking our research, there were only three existing studies examining the distribution of IPC sites, all of which examine patterns of distribution against social class (measured as income or indicators of deprivation). This focus on social class is typical of the emerging environmental justice field in the UK generally and reflects different political priorities to the US where race has been the dominant concern (Ayegman and Evans 2004). The first study by Friends of the Earth (FoE) (2000) was groundbreaking in constituting the first large scale empirical environmental justice study undertaken for any topic in the UK. This examined IPC site locations against average income estimates for postcode sectors in England and Wales and found a strong bias towards low income areas - 662 IPC sites were located in areas with an annual average household income of less than £15 000, with only 6 factories in areas where average annual incomes were greater than £30 000. A second study by FoE (2001) analysed levels of carcinogenic emissions from IPC sites against the index of deprivation at ward level for England and found that 82 % of carcinogen emissions occurred in the most deprived 20% of wards (FoE 2001). A simple analysis undertaken by the Environment Agency (2002) also analysed the locations of IPC sites in England against the index of multiple deprivation, using a measure of number of sites per square kilometre within wards. In line with the FoE results this found a strong relationship, with the density of IPC sites increasing as deprivation increases. A later study by Wheeler (2004) included IPC sites in a complex analysis of environmental indices against various indicators of deprivation derived from the census. He found that an emission index constructed for IPC sites was consistently related to deprivation across four groupings of census wards – wholly urban, predominantly urban, urban-rural and wholly rural.

At the point of embarking on our project the existing evidence base was very limited and when compared to some of the 'better quality' studies undertaken in the US, exhibited two key methodological weaknesses (Liu 2001, Mitchell and Walker 2005). First, the relationship between site and surrounding population had been evaluated simply through the location of each site in an area delineated for administrative purposes (wards or postcode sectors). Second, all IPC sites had been treated as equal with no differentiation in the analysis to reflect the different scale of operations and/or characteristics of emissions to different environmental media. Our project research design therefore sought to attend to both these methodological weakness - although as discussed later could not fully resolve either.

Methods of Analysis

In order to relate the IPC and deprivation data two approaches were taken to spatial analysis:

1) a simple 'spatial coincidence' analysis counting sites in census wards;
2) a buffer analysis, delineating a circle around each site within which population deprivation characteristics could then be analysed, taking account of population distribution within the circle.

The second of these two approaches is superior in that each site is treated consistently in terms of the size and shape of spatial unit that is 'attached' to the site, rather than relying upon the administrative geography of ward shapes and sizes (Liu 2001). It also takes account of the fact that some areas around IPC sites may in fact be largely or entirely devoid of people by using postcode data to estimate numbers of people within the circle around each site (see Walker et al 2003 for a detailed discussion of the method applied). Hence the focus in this second method is on numbers of people at risk (and their deprivation characteristics) rather than assuming that each IPC site affects similar numbers of people, or that people are equally distributed within a ward or buffer area. In drawing circles around sites we used four distances (500m, 1km, 2km, and 4km) which on the advice of the Agency represented the range of likely spatial extents for airborne emissions. Using buffers also enabled us to examine the occurrence of site clustering and the characteristics of people living near to multiple IPC sites (analysis which has rarely been undertaken in any previous studies; Krieg and Faber 2004).

Three methods were used to differentiate between IPC sites and to explore their salient characteristics, rather than treating all sites as equal:

1) data analysis was undertaken not just for numbers of sites, but also for the number of authorizations at these sites and numbers of separate authorized emissions (Each IPC site can have more than one polluting process and each of these processes has to have a separate authorisation). Each authorisation then has an often long list of permitted emissions of different substances to different environmental media. The significance of these elements of the 2001 IPC inventory database can be seen by the fact that it included 1131 sites, but 1467 authorisations and 11484 emission sources.

2) the sites were divided into the six main industrial sectors identified in the IPC regulations to see if different patterns existed for different types of polluting industry.

3) the scores assigned to each IPC sites under the Operator and Pollution Risk Appraisal (OPRA) system were used to differentiate between the levels of hazard and noxious emissions from each site (Environment Agency 1997). Scores are given by Environment Agency inspectors to authorised processes against 7 criteria (see Table 1) which are combined to give an overall Pollution Hazard Appraisal score.

[TABLE 1 HERE]

The PHA score provides a way of differentiating the pollution hazard presented by different sites in a qualitative but locally informed and holistic manner – account is taken not only of total emissions but also factors of toxicity, the nature of operations and the existence of pollution control systems. Attempting to differentiate between sites on the basis of substance by substance emissions data in the pollution inventory (as for example attempted in a number of US studies, Liu 2001) would be far more involved, but also far cruder.

In order to relate IPC site locations and characteristics to deprivation, the Index of Multiple Deprivation (IMD) for 2000 was used at ward level. The IMD has become the most widely used official data set on deprivation in the UK, and provides a ranked overall deprivation score, constructed from six separate domains addressed by 33 separate indicators (DETR, 2000). Using this composite index provides a multidimensional measure of deprivation, but there are some limitations arising particularly from the way in which the 'access to services' domain is inversely associated with the other five domains. Because of the method of calculation, a ward with an IMD rank of 100 is not necessarily twice as deprived as a ward with a rank of 200. For this reason the deprivation analysis was undertaken by dividing all of the wards into ten population weighted deciles, from least to most deprived, which maintain the ranked ordinal form of the data. In order to create these deciles wards were first ranked in terms of deprivation, and the deprivation ranked wards placed into deciles of approximately equal population (see column 2 in Table 3). Deciles of *equal population* are preferred to those of equal ward count as the analysis then gives a population based, not area based distribution of polluting industrial sites.

Given the ordinal nature of the deprivation data some of the statistical techniques typically used in environmental justice studies (such as correlation and regression analysis) were not appropriate. We therefore calculated the Concentration Index (CI) for each distribution across the deciles in order to provide a comparative statistical indicator of inequality. The CI is closely related to the simpler Gini coefficient which has been widely adopted as a measure of income and health inequalities (Wagstaff *et al*. 1991) and also recently applied to environmental equity research (Lejano *et al*. 2002). A value of zero indicates complete equality (i.e. the proportion of the population living near to an IPC sites would be identical for all deprivation deciles) whilst values of 1 and -1 indicate extreme inequality in positive or negative relationships with deprivation[2].

Spatial patterns of industrial pollution against social deprivation

The discussion of results for England begins with an overview of general patterns of IPC site distribution without differentiating between different types of sites or site characteristics. Different forms of differentiation and approaches to analysis are then introduced.

Using the ‘spatial coincidence’ method of analysis, Table 2 shows that for sites, authorisations and emissions there is a strong relationship with deprivation. Wards in the most deprived decile (number 1) providing the location for five times as many sites and authorisations and seven times as many emission sources as the wards in the least deprived decile (number 10). As indicated by the CI values, counting sites provides the marginally weaker relationship with deprivation, whilst counting emission sources provides the strongest, indicating that the sites in the more deprived wards have a greater number of emissions per site (on average) than sites in the less deprived wards.

[TABLE 2 HERE]

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[2] The CI does not provide an indicator of the *significance* of inequality, which will always be an ethical and political judgement, and is best used in a comparative setting. It is useful to note, however, that the value for income inequality in the UK from 1979 to 2001 has increased from 0.25 to 0.35 (Shephard 2003). Gini values for income inequality in the USA, by comparison, are currently around 0.45.

Repeating the analysis using the buffer method (Table 3) produces a similar but more accentuated relationship with deprivation. The disproportionate concentration of the most deprived populations near to IPC sites is highlighted, with the highest percentage consistently in the most deprived decile for all 4 buffer distances, followed by an almost universally consistent fall through to the least deprived decile. The CI values for the 500m, 1km and 2km buffers all indicate a greater inequality than the CI value of 0.22 for the site in ward count method. For the ward count method the ratio between least and most deprived ward decile is 4:1 – there are four times more sites in decile 1 compared to decile 10. For the site buffer method the ratios are between 5:1 and 6:1 for the buffer distances 500m, 1km and 2km. The fall in CI values between the 500m and 2km distances indicate that the concentration on deprived populations is most acute for the area closest to the site, where some impacts from the IPC site (but not necessarily all) are likely to be the most significant.

[TABLE 3 HERE]

These patterns can also be seen in Figure 1 which charts an indexed ratio for each buffer distance. The index is derived by setting the value for the least deprived ward decile at 1 in each case. The relationship between IPC site location and the deprivation characteristics of wards near to IPC sites is again starkly clear, as is the close correlation between the 500m, 1km and 2km profiles.

The results from the 'counting people' in buffer method give no indication of those people who are living within 1km of two or more sites (i.e. where buffers overlap) and therefore whether or not IPC sites are clustered in areas of higher levels of deprivation. A further more involved analysis was therefore carried out to examine the deprivation characteristics of people living within 1km of two or more sites. Contrasting the most and least deprived deciles, Table 4 shows that there are 159,031 people in the most deprived decile living near to 2 or more sites, and only 13,301 in the least deprived. There are *no* people living near to 4 or more sites in the least deprived decile, compared to 11,523 in the most deprived. As the number of sites within 1km rises the bias towards the more deprived deciles becomes more acute – as shown by the graduation of CI values rising from 0.31 to 0.59.

[TABLE 4 HERE]

Within the IPC regime, sites are categorised into one of six industry sectors – chemical, fuel and power, metal, mineral, waste and other. Figure 2 shows the results of the 1km buffer analysis differentiated by industry sector, using an index ratio standardises upon the lowest decile in each sector (i.e. the lowest decile is given a value of 1). This enables a comparison of the difference between the least deprived decile and other deciles sector by sector. All of the sectors show an inequality bias towards the more deprived deciles, although for the mineral sector this is significantly less marked, whilst the waste sector[3] stands out as particularly extreme (CI value of 0.45). The proportion of the population in the most deprived decile living within 1km of an IPC waste site is 43 times higher (113,768 people) than in the least deprived decile (2,619 people).

[FIGURE 2 HERE]

OPRA pollution hazard appraisal (PHA) scores (see above) for authorized processes were next used to analyse the distribution of pollution hazard. Scores range from Band A, denoting low hazard, to Band E,(High hazard). The majority of authorisations fall into PHA band C with very few in the lowest hazard band A, and none in the highest band E (Figure 3). The dominance of Band C authorisations makes differentiation difficult . However, the higher hazard band C and D authorisations are more prevalent in the more deprived deciles in absolute *and* relative terms. For example, there are 55 sites with the highest pollution hazard rating (Band D) in the most deprived 20% of wards, compared to only 4 in the 20% least deprived. Band A and B authorisations have a more uniform social distribution. The graduation in CI values also demonstrates the more equal distribution of low hazard sites and

[3] IPC waste sites are mainly incinerators. Landfills were not included within the IPC regime.

the bias towards more deprived deciles for high hazard sites. There are therefore more IPC sites, and more high hazard IPC sites, in deprived wards compared to more affluent wards.

[FIGURE 3 HERE]

An element of the PHA rating which is particularly relevant to the day to day experience of living near an IPC site is the score given to 'offensive characteristics' that are likely to give 'local annoyance'. This is measured over a range of 1 (least offensive) to 5 (most offensive). In absolute terms there is again a far higher number of authorisations with offensive characteristics in the high deprivation bands than in the lower ones (Figure 4). For the worst scores on the offensiveness rating (4 and 5) there are 52 authorisations in wards in the most deprived decile, compared to 9 in the least deprived decile. In relative terms there is also a bias towards the more deprived deciles – the CI value for authorisations with a score of 5 is 0.34 indicating a greater inequality than the value of 0.26 for all authorisations.

[FIGURE 4 HERE]

Evaluating the Evidence

Our analysis provides evidence of a socially unequal distribution of IPC sites in England. These significant sources of pollution are disproportionately located in more deprived areas - as measured both by a count of sites in wards and through analysis of the deprivation characteristics of populations living within a range of distances from each site. IPC sites are also more clustered in deprived areas, with the proportion of people living within 1km of multiple sites higher than in more affluent areas. On average, IPC sites in deprived areas have more frequent emissions and present a greater potential pollution hazard, as indicated by the Environment Agency authorisation OPRA scores. IPC sites in deprived areas tend also to produce more 'offensive' pollutants which are likely to have an impact on the day-to-day quality of life of local people. Waste sites, in particular, stand out as being disproportionately located within deprived communities.

Such evidence is initially compelling and suggests, as in other areas of policy in which striking inequalities exist such as for income or health, that there is a case for some form of public intervention. However, experience in the US and the methodological issues being emphasized in recent discussion (Mitchell and Walker 2005), indicate the need for caution in moving too readily from empirical results to policy prescription. Whilst the analysis we have undertaken provides a significant advance on the existing limited research base, it needs to be evaluated in the light of the complexities involved in undertaking such distributional analysis and in substantiating claims of injustice. These complexities can be most readily approached through a consideration of what the evidence is *not* able to show:

Impact and harm – the analysis provides evidence of patterns of proximity, it does not show patterns of pollution impact and/or demonstrable harm in terms of human health. Whilst proximity, assessed by a circle drawn around a site grid reference, may be used as surrogate for impact or harm it is a poor one across the range of types of installation included in the IPC category. As Davidson (2003) emphasizes, the question of siting is distinct from the question of risk, as the risk of harm from any one polluting site is dependent on a wide range of variables such as emission types and levels, patterns of dispersal and distribution and the exposure and response of particular people to the pollution. A circular measure of proximity cannot represent this range of variables, which ideally would be evaluated through site by site risk assessments. This would entail much uncertainty and the commitment of very substantial resources (Davidson 2003, Bullard 1994). However, for some impacts, such as visual impacts and 'place stigma', proximity may be considered a better quality surrogate.

Causation – whilst a pattern of unequal distribution has been identified this does not begin to explain why the pattern of unequal distribution exists. It is possible to hypothesis as to potential contributory factors which might include: (i) the operation of housing and land markets over long time scales; (ii) land use planning policies which have agglomerated industrial activities in areas with poorer environmental quality; (iii) historic patterns of site location and associated housing for workers and (iv) deliberate targeting of deprived areas by companies seeking to gain planning permission where local opposition is likely to be less substantial, influential and well organized. Such processes of causation have been examined in US studies through historical and contextual approaches to understanding the development of inequity through detailed description of patterns of community and industrial evolution (e.g. Pulido *et al*. (1996) and Hurley (1995); and also through longitudinal statistical analyses comparing the social characteristics of nearby populations at the time when installations were first sited to those of the present day (e.g. Anderton *et al*. 1994; Baden and Coursey 2002). However, unpicking causative factors beyond the local level and establishing clear discriminatory intent in siting have in practice proved very difficult to achieve (Bowen 2002).

Injustice – the results of our analysis clearly show a pattern of inequality in the distribution of IPC sites, but this does not immediately imply a condition of inequity or injustice and the need for policy intervention. As Low and Gleeson (1998) emphasise both the quality of the environment and the justice of its distribution may be evaluated in different ways and there is "*no universal prescription of what is a fair distribution of environmental quality for any scale of analysis*". Questions of fairness are ethical and political, rather than empirical and statistical, and may be judged on factors which are not just distributional but also include issues of procedural equity and the availability and application of personal and/or communal choice. Questions of vulnerability and need for protection also interact with issues of fairness where health concerns are predominant (given that the health impacts of environmental exposure may be modified by socio-economic status; Jerrett et al 2004). Table 5 lists a number of possible grounds on which a judgement of injustice in the location of IPC sites and need for policy intervention could be made, emphasising the different factors and perspectives potentially involved. Each of these also implies the need for different types of evidence and analysis to inform the judgements that are made, and involve different degrees of concern for questions of causation.

As noted by Low and Gleeson scale is also important. Spatial distributions are always evaluated at a particular scale, in our case for England as a whole. However, different results may have been obtained, and different judgements of fairness made, if we had worked at a regional or city level, evaluating the distribution of a subset of IPC sites across a subset of space and population. The influence of spatial choices was emphasised in our work by the fact that we were forced to carry out an analysis separately for Wales because of the different structure of the IMD for Wales (Walker et al 2003). This showed much weaker relationships with deprivation for IPC site location than for England (and in some cases inverse patterns) which would have been masked if an analysis combining English and Welsh data, as originally intended, had been possible.

[TABLE 5 HERE]

Conclusion

The term environmental justice provides a useful ‘vocabulary for political opportunity’ (Agyeman and Evans 2004) providing a means to highlight questions of distribution and procedural fairness across a wide range of environmental policy domains (Stephens et al 2001, Lucas et al 2004). In the UK, the discourse of environmental justice is beginning to take shape and is in many ways distinct from the US experience in terms of its driving forces, breadth and focus. However, there are still opportunities to learn from the process of reflection and re-evaluation that has recently featured in the US literature and the complexities of methodology, research-policy relationships and policy responses that have emerged (Foreman 1998).

The analysis of IPC site locations in relation to patterns of social deprivation that we have outlined in this paper, incorporates significant methodological advances on previous UK research and has sought to avoid some of the weaknesses identified in earlier US studies. The results do show distinct patterns of inequality in the distribution of IPC sites when analysed across England as whole and provide empirical confirmation of assumptions that have in the past been too easily made about the social gradient of industrial pollution (Beck 1995). We have emphasized though, the need to be clear about what the research does *not* show, particularly in terms of patterns of impact, exposure and risk, processes of causation and claims of injustice. There are also specific methodological issues which we have not had the space to discuss in this paper regarding the coverage and accuracy of the IPC database, the choice of wards as the spatial unit and the ecological fallacy of assuming that all people within a ward are equally deprived (see Mitchell and Walker 2005).

In this light, we would argue that empirical research of this form, at a national scale and examining broad relationships between environmental and social variables, whilst having an important role in the development of the environmental justice field, can only be a starting point in the process of opening up relevant issues, questions and policy debates. Whilst methodological development, as well as the carrying out of studies for different environmental and social variables at different scales (regional, local and international) is needed, the policy community more fundamentally needs to begin to grapple with some of the difficult implications that arise when issues of social justice are brought to bear on previously socially-blind (or agnostic) regulatory traditions. From our experience of discussing the results of the project with those involved in the management of industrial pollution, both within and outside of the Environment Agency, it is clear that justice and equity are not easily assimilated into current policy and practice but have difficult, transgressive qualities. Boundaries of responsibility and remit are challenged and principles of regulation, such as the 'level playing field' treatment of all companies in the same way regardless of location, are potentially undermined (Holifield 2004). Whilst we cannot give sufficient attention here to the wide range of policy implications involved, it is clear that environmental justice cannot be treated simply as a 'technical issue', amenable to empirical analysis and technocratic resolution (Foreman 2003). Ethical and political judgments have to be made to, for example, resolve what a 'disproportionate impact' might be and how both the national regulatory or land use planning system and the communities experiencing that impact might wish it to be responded to. For as Dobson (1998) and Low and Gleeson (1998) and many others have made clear, polluting industrial sites can never be 'equally' distributed (whatever that might mean) and in this light the pursuit of greater environmental equity or justice must always be partial, relative and brought to bear not on sharing pollution out, but reducing its production at source.

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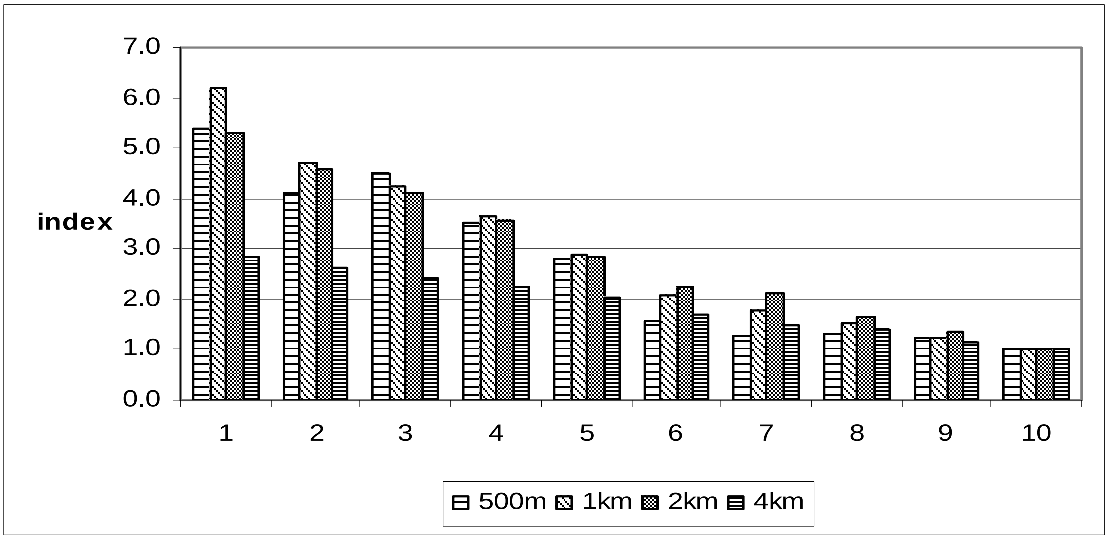
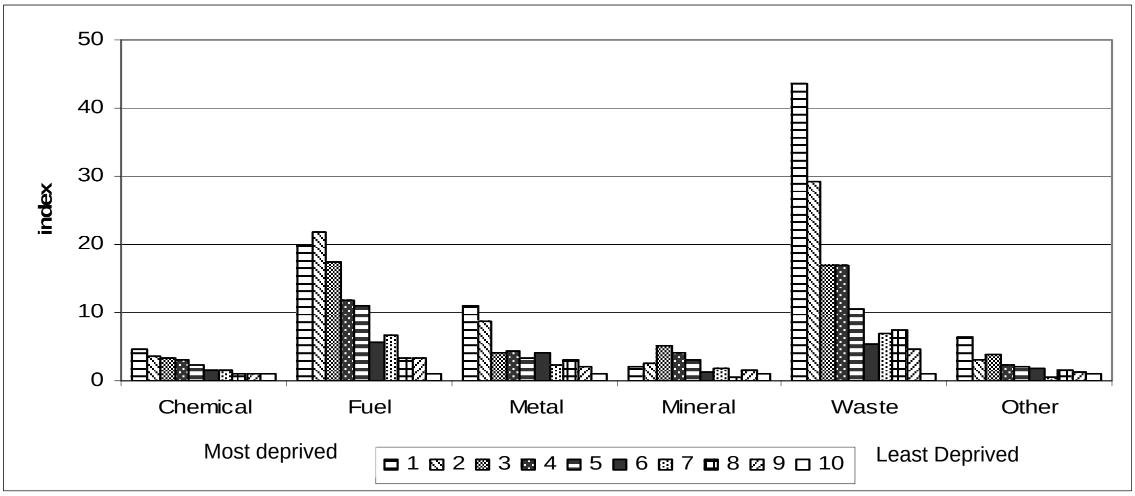
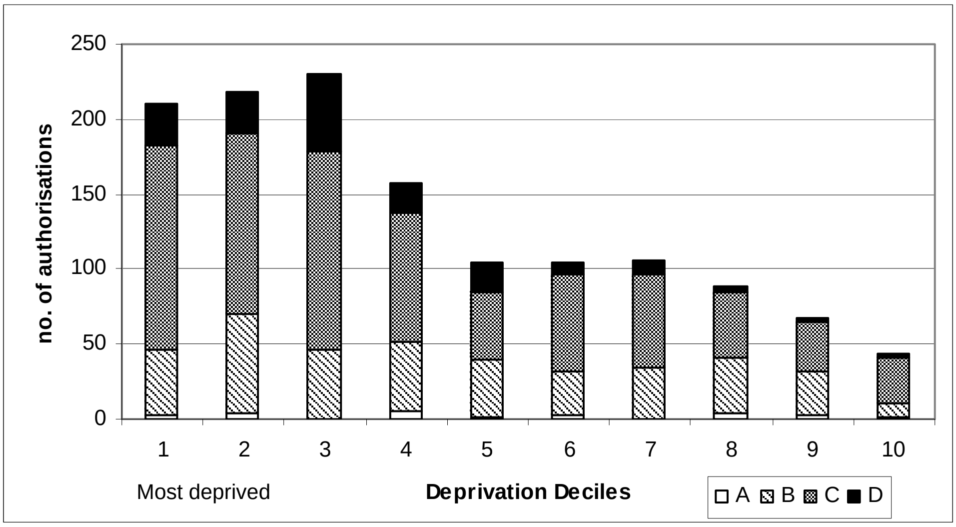


Figure 1: Index Ratio between the proportion of people living in the least deprived deciles (=1) and other deciles for four distances from IPC sites in England (500m, 1km, 2km and 4km).



Concentration Index Values						
All sites	Chemical	Fuel	Metal	Mineral	Waste	Other
0.31	0.29	0.38	0.34	0.21	0.45	0.34

Figure 2: Index of ratio between least deprived and other ward deciles for proportion of population within 1km of IPC sites in different industry sectors (index = 1 for decile 10, apart from minerals where 1 = decile 9)



Concentration Index Values					
A	B	C	D	E	All authorisations
0.07	0.17	0.28	0.4	No data	0.26

Figure 3: Pollution Hazard Appraisal (PHA) scores of authorisations located in population weighted deprivation deciles (A = low pollution hazard, D = high)

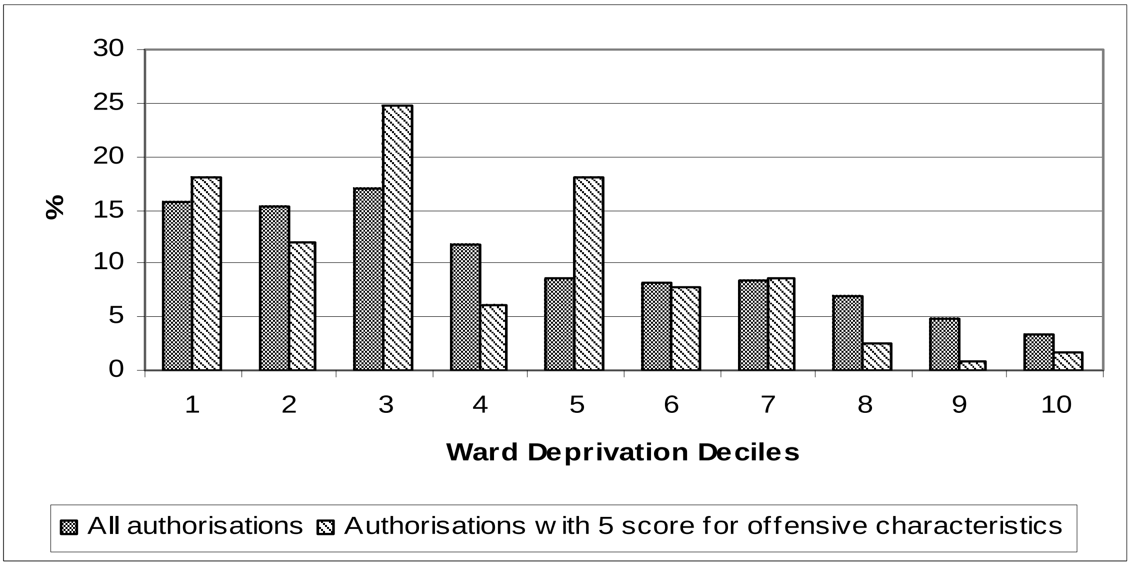


Figure 4: Percentage of all authorisations and authorisations with a maximum 5 score for offensive characteristics against population weighted ward deprivations deciles for England.

Tables for Local Environment Paper

Table 1: The Pollution Hazard Appraisal scoring criteria

1. Presence of hazardous substances – what is stored
2. Scale of hazardous substances – what could be emitted
3. Frequency and nature of hazardous operations – how complicated the process is
4. Technologies for hazard prevention and minimisation – how the hazard is controlled at source
5. Technologies for hazard abatement – how environmental emissions are reduced
6. Location of process – how sensitive the local environment is to pollution
7. Offensive characteristics – whether emissions are likely to cause local annoyance (such as smell).

Table 2: Totals and percentages of sites, authorisations and emissions by population weighted ward deprivation decile for England (using 'site in ward' counting method)

	Number			**%**		
Decile	**Sites**	**Authorisations**	**Emissions**	**Sites**	**Authorisations**	**Emissions**
1	154	231	1751	15	16	15
2	162	226	2031	16	15	18
3	142	248	1644	14	17	14
4	130	173	1464	13	12	13
5	97	125	1036	9	9	9
6	92	121	1080	9	8	9
7	85	122	1017	8	8	9
8	77	101	805	7	7	7
9	56	71	401	5	5	3
10	36	49	255	3	3	2
Totals	*1031*	*1467*	*11484*	*100*	*100*	*100*
CI	**0.22**	**0.25**	**0.26**			

Table 3: Total and percentage populations living within 500m, 1km, 2km and 4km of an IPC site by population weighted deciles for England.

Decil e	Total Population	Population within 500m of an IPC Site		Population within 1km of an IPC Site		Population within 2km of an IPC Site		Population within 4km of an IPC Site	
		Total	%	Total	%	Total	%	Total	%
1	4,943,800	162,948	20.1	761,064	21.1	2,166,331	18.4	4,025,003	15.0
2	4,953,600	124,390	15.4	582,092	16.1	1,872,031	15.9	3,719,323	13.9
3	4,940,000	136,445	16.9	521,329	14.5	1,682,984	14.3	3,434,683	12.8
4	4,947,900	106,566	13.2	450,845	12.5	1,460,468	12.4	3,169,473	11.8
5	4,948,200	84,763	10.5	355,828	9.9	1,167,286	9.9	2,893,713	10.8
6	4,952,700	47,973	5.9	257,231	7.1	928,658	7.9	2,415,685	9.0
7	4,938,400	38,314	4.7	218,868	6.1	868,910	7.4	2,102,571	7.9
8	4,955,400	39,429	4.9	185,528	5.1	677,725	5.7	1,969,142	7.4
9	4,951,500	37,764	4.7	149,044	4.1	561,447	4.8	1,621,068	6.1
10	4,959,600	30,342	3.8	123,058	3.4	410,065	3.5	1,408,857	5.3
Totals	*49,491,100*	*808,933*	*100*	*3,604,888*	*100*	*11,795,904*	*100*	*26,759,518*	*100*
CI Values		*0.31*		*0.31*		*0.27*		*0.18*	

Table 4: Numbers of people living within 1km of multiple sites by population weighted ward deprivation deciles for England

Decile	5 or more sites	4 or more sites	3 or more sites	2 or more sites	1 or more sites
1	2,613	11,523	34,878	159,031	761,064
2	2,077	6,469	28,915	127,984	582,092
3	4,865	9,544	32,710	110,211	521,329
4	1,212	4,424	23,890	86,773	450,845
5	47	1,793	5,111	32,023	355,828
6	248	1,586	8,893	32,860	257,231
7	18	80	5,226	28,236	218,868
8	0	0	1,630	16,948	185,528
9	0	0	3,392	15,486	149,044
10	0	0	272	13,301	123,058
Total	*11,079*	*35,419*	*144,917*	*622,854*	*3,604,888*
CI	0.59	0.59	0.48	0.44	0.31

Table 5: Potential grounds for claims of injustice in IPC site locations and the need for policy intervention to address this

The deprived are taking an unfair burden of negative impacts from industrial sites	Distributional
The deprived are taking an unfair burden of negative impacts from industrial sites and they are also more vulnerable to pollution impacts	Distributional and Protective
Industrial pollution adds to other environmental and social inequalities focused on the same deprived areas	Cumulative Distributional
The processes by which decisions to locate IPC sites are made are or have been unfair	Procedural
People that are deprived are less able to exercise free choice in where they live	Procedural and Distributional
Communities experiencing a disproportionate burden are not adequately compensated by benefits from the industrial activities	Distributional and Utilitarian